INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

D V C SPECIAL NUMBER

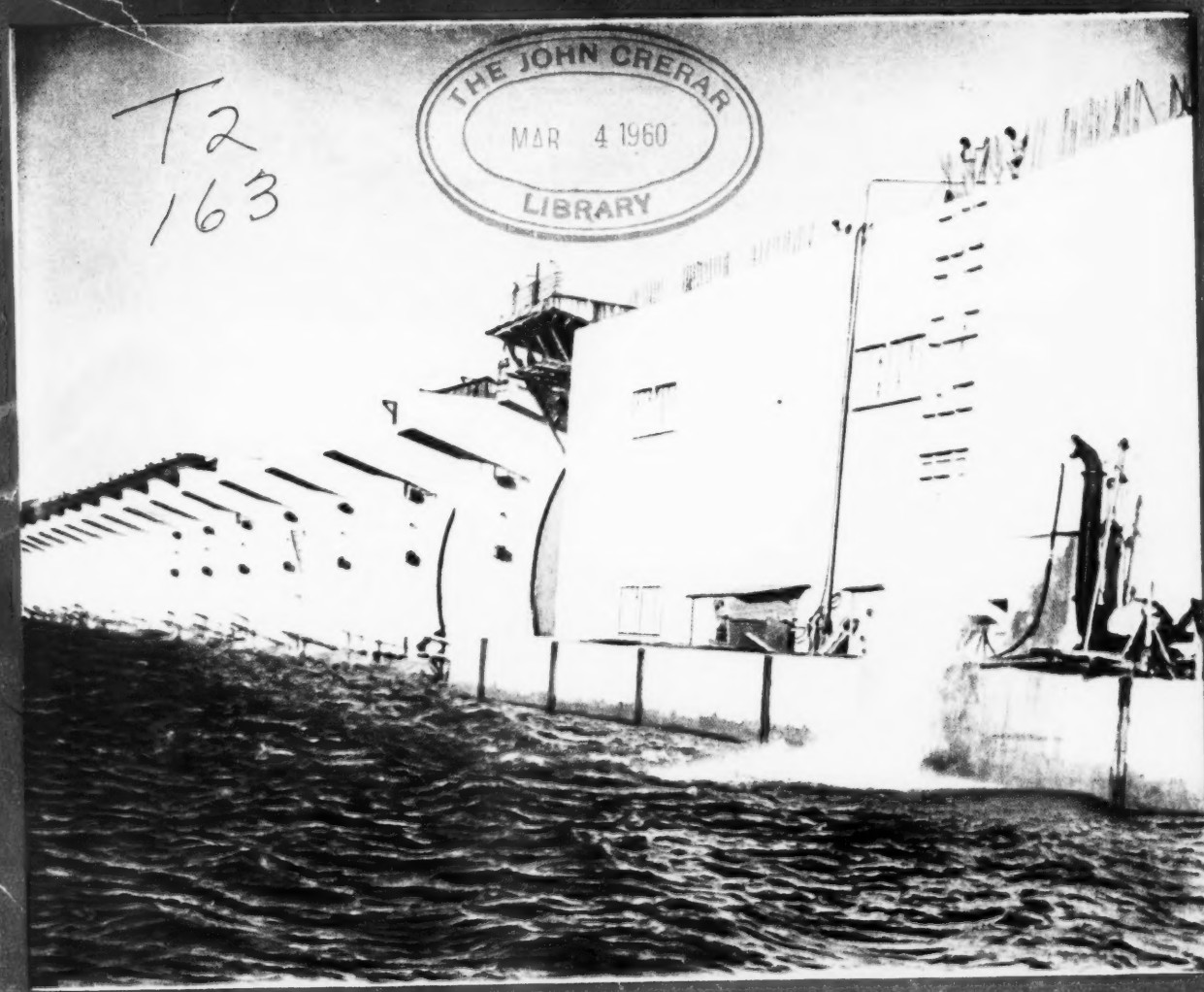
ISSUED ON THE OCCASION OF THE INAUGURATION OF THE PANCHET HILL PROJECT

VOL. IX NO. XI

RS. 7-50

THE JOHN CRERAR
MAR 4 1960
LIBRARY

T2
163



UPSTREAM VIEW OF THE PANCHET HILL DAM

xcavation for Vital Projects

RUSTON-BUCYRUS

of course

– there could'nt have been a better choice

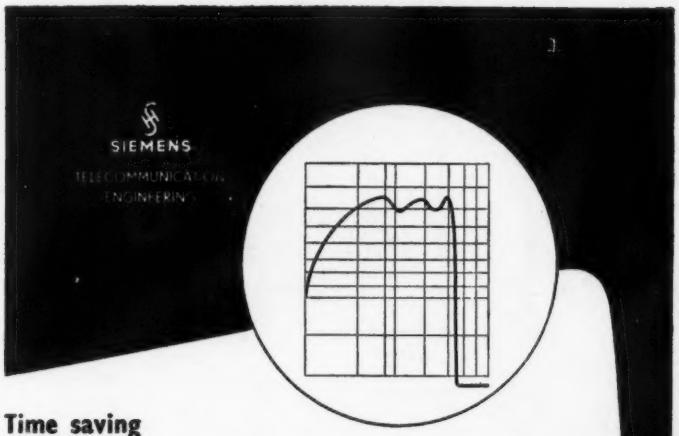
54 R. B. Excavator at Rihand Project

Sole Concessionaires :

GREAVES COTTON & CO. LTD.

Bombay • Calcutta • Ahmedabad • Bangalore • Coimbatore • Kanpur • Madras • New Delhi

Ralli House, 16 Hare Street, Post Box 702, Calcutta 1.



Time saving instruments

find always an important place in the development, manufacturing and testing of communication networks, because the measuring values of level, loss, impedance etc. as a function of frequency are reproduced instantaneously on the Cathode Ray Tube. Along with other instruments it is possible to localise the faults on transmission lines and to take routine measurements without interrupting the operation of multi-channel carrier telephone circuits

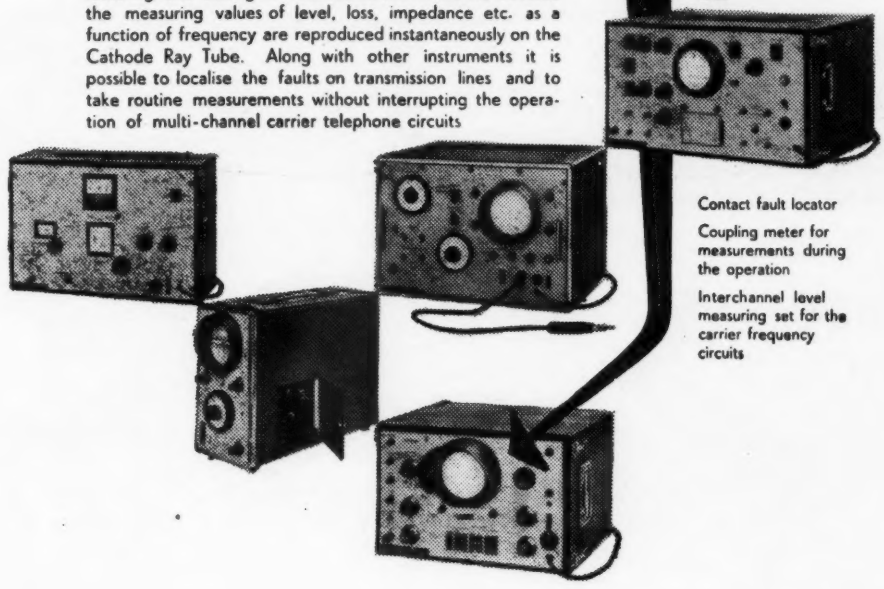
OUR MANUFACTURING PROGRAMME INCLUDES:

Level Tracer

Sweep frequency oscillator and level tracing receiver

Sweep frequency measuring equipment

Echoscope for fault location on telephone lines



Contact fault locator

Coupling meter for measurements during the operation

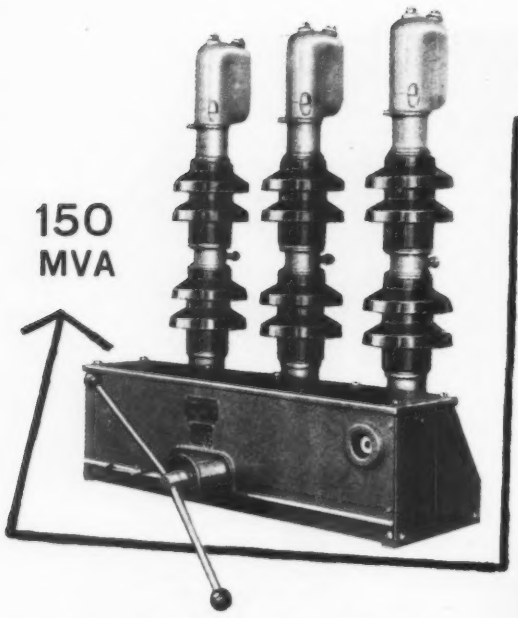
Interchannel level measuring set for the carrier frequency circuits

SIEMENS & HALSKE AKTIENGESELLSCHAFT
BERLIN - MUENCHEN

SOLE REPRESENTATIVES:
SIEMENS ENGINEERING & MANUFACTURING CO. OF INDIA PRIVATE LTD.

BOMBAY	CALCUTTA	NEW DELHI	MADRAS	BANGALORE
G.P.O. Box No. 490	G.P.O. Box No. 715	P.O. Box 543	36, Mount Road	9, St. Mark's Road

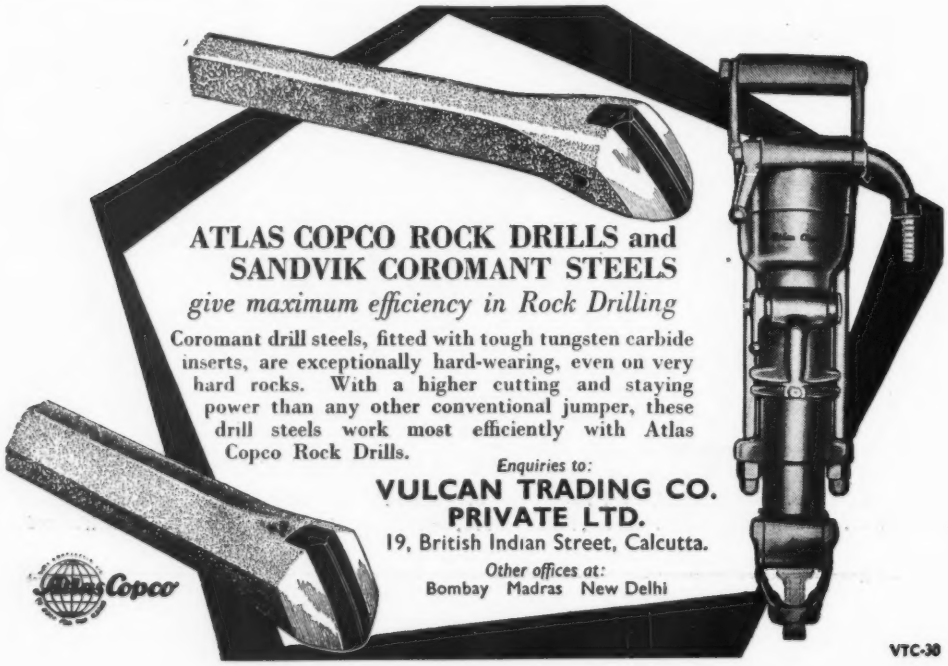
9-35



type tests performed at the official Laboratory of KEMA

SCARPA & MAGNANO

Head Office & Works: SAVONA (Italy) VIA FIUME 2
Comm. Management: MILAN (Italy) VIA MANZONI 12



ATLAS COPCO ROCK DRILLS and SANDVIK COROMANT STEELS

give maximum efficiency in Rock Drilling

Coromant drill steels, fitted with tough tungsten carbide inserts, are exceptionally hard-wearing, even on very hard rocks. With a higher cutting and staying power than any other conventional jumper, these drill steels work most efficiently with Atlas Copco Rock Drills.

Enquiries to:

VULCAN TRADING CO. PRIVATE LTD.

19, British Indian Street, Calcutta.

Other offices at:

Bombay Madras New Delhi

Atlas Copco

VTC-30

YEARS OF LEADERSHIP

The world's oldest and largest manufacturer of tapered roller bearings

What do you get when you buy Timken tapered roller bearings? You get 60 years of leadership in designing, making and improving tapered roller bearings. You get all the experience that goes into making bearings of unequalled accuracy—as fine as 75 millionths of an inch run-out tolerance. You get the finest steel because it's made to our careful specifications.

Leading manufacturers the world over specify Timken tapered roller bearings because for 60 years, they've been the number one bearing value.

Get the most for your money. Specify Timken tapered roller bearings for the next machines you buy or build. Available world-wide. The Timken Roller Bearing Company, Canton 6, Ohio, U.S.A. Cable Address: "TIMROSCO"

Industry rolls on

TIMKEN®

REGISTERED TRADE-MARK

tapered roller bearings

Authorised industrial and railway distributor:

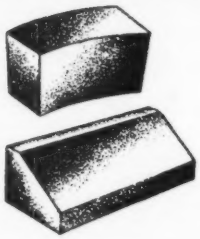
Voltas Limited • Bombay • Calcutta • Madras • New Delhi • Bangalore • Cochin.

ACC'S SUPER QUALITY ALUMINOUS REFRACTORIES

...are available with medium, high and super alumina content, to meet all your requirements;

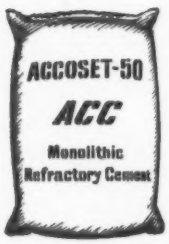
...are made to the shape, size and quality you require;

...have great resistance to spalling and abrasion and are more economical than ordinary firebricks.



AND NOW THE ACC INTRODUCES TWO REFRACTORY CEMENTS

ACCOSET-50 and ACCOCID



ACCOSET-50
is a Monolithic Refractory Cement. It is a highly refractory mortar furnished with air-setting properties and can withstand a temperature of 1710° C.

Recommended for:
monolithic constructions, laying up and coating ordinary and high-alumina bricks, making repairs and filling patches in walls, arches and other parts of the furnace, etc.

ACCOCID
is a special acid and alkali-proof cement.

Recommended for:
laying of acid-proof bricks and tiles, and can also be used as a lining to resist the corrosive action of acids and alkalies.

THE ACC ALSO MANUFACTURES **ACID-PROOF BRICKS**

For further particulars write to:

The Cement Marketing Co. of India Private Ltd.

Head Office: 'Cement House', 121, Queen's Road, Bombay

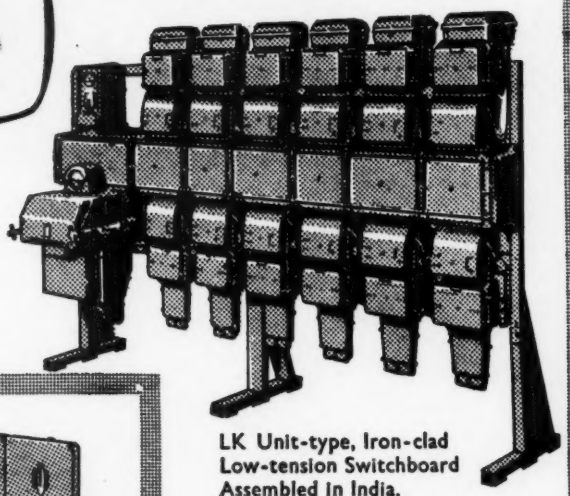
Branches at: Delhi - Kanpur - Patna - Calcutta - Secunderabad - Coimbatore Bangalore - Ahmedabad - Indore - Madras

THE ASSOCIATED CEMENT COMPANIES LIMITED
The Cement Marketing Co. of India Private Ltd.

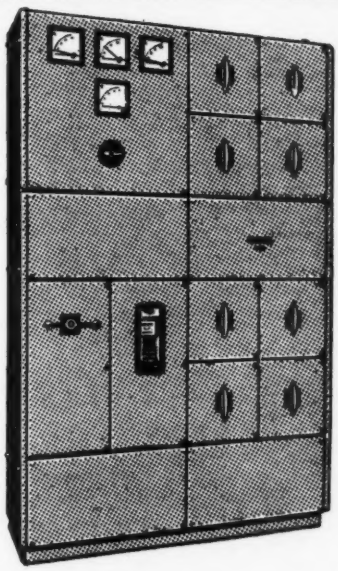
CHI. 9728

ACC
—an achievement of Free Enterprise

LK
SWITCHGEAR



LK Unit-type, Iron-clad
Low-tension Switchboard
Assembled in India.



LK Sheet-Steel, Cubicle-type
Low-tension
Switchboard.

Manufactured by

LAUR KNUDSEN

COPENHAGEN, DENMARK

Low-tension Switchboards designed for tropical service.

Incorporating

Heavy Duty, Industrial Type
100—1,500 A Oil Circuit Breakers
200—10,000 A Air Circuit Breakers
15—1,000 A HRC Switch-and-Fuse units,
Instruments, Relays, Meters etc.

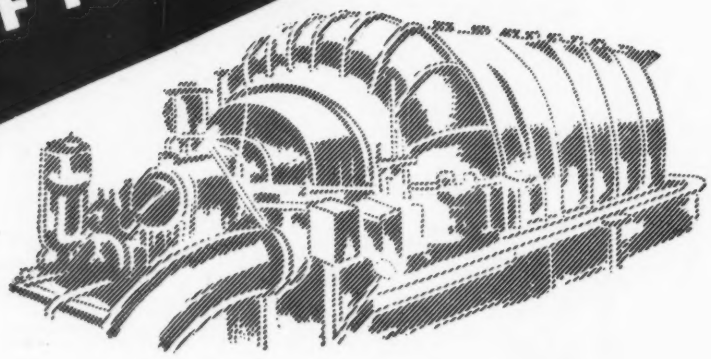
LARSEN & TOUBRO LIMITED

BOMBAY P.O. BOX 278 · CALCUTTA P.O. BOX 619 · MADRAS P.O. BOX 524
BANGALORE P.O. BOX 98 · COCHIN P.O. BOX 55 · NEW DELHI P.O. BOX 131

SWT/G/59

A DE LAVAL OIL PURIFIER

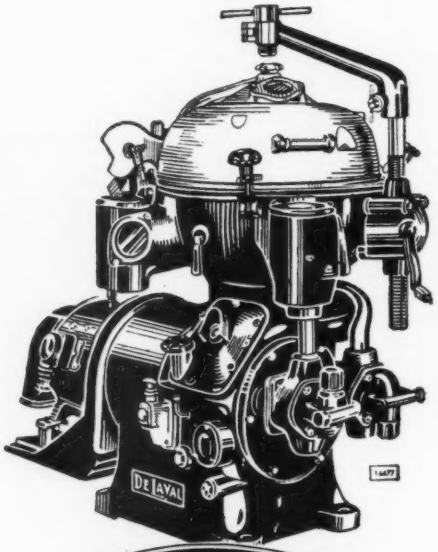
KEEPS TURBINES OUT OF TROUBLE



Instal a De Laval Centrifugal Oil Purifier at only a fraction of the cost of your power unit and instantaneously remove all traces of water, dust and sludge from your lubricating oil and still retain the valuable oxidation inhibitors added by the refiner. By most effectively utilizing centrifugal force a De Laval Oil Purifier keeps turbine oil so clean that it can be used indefinitely.

Also instal De Laval Separators for transformer oil, diesel fuel oil, vanaspati factories, power alcohol distilleries, starch and hundreds of other industries.

A complete range of spares for all types of De Laval Units are readily available from stocks in India.

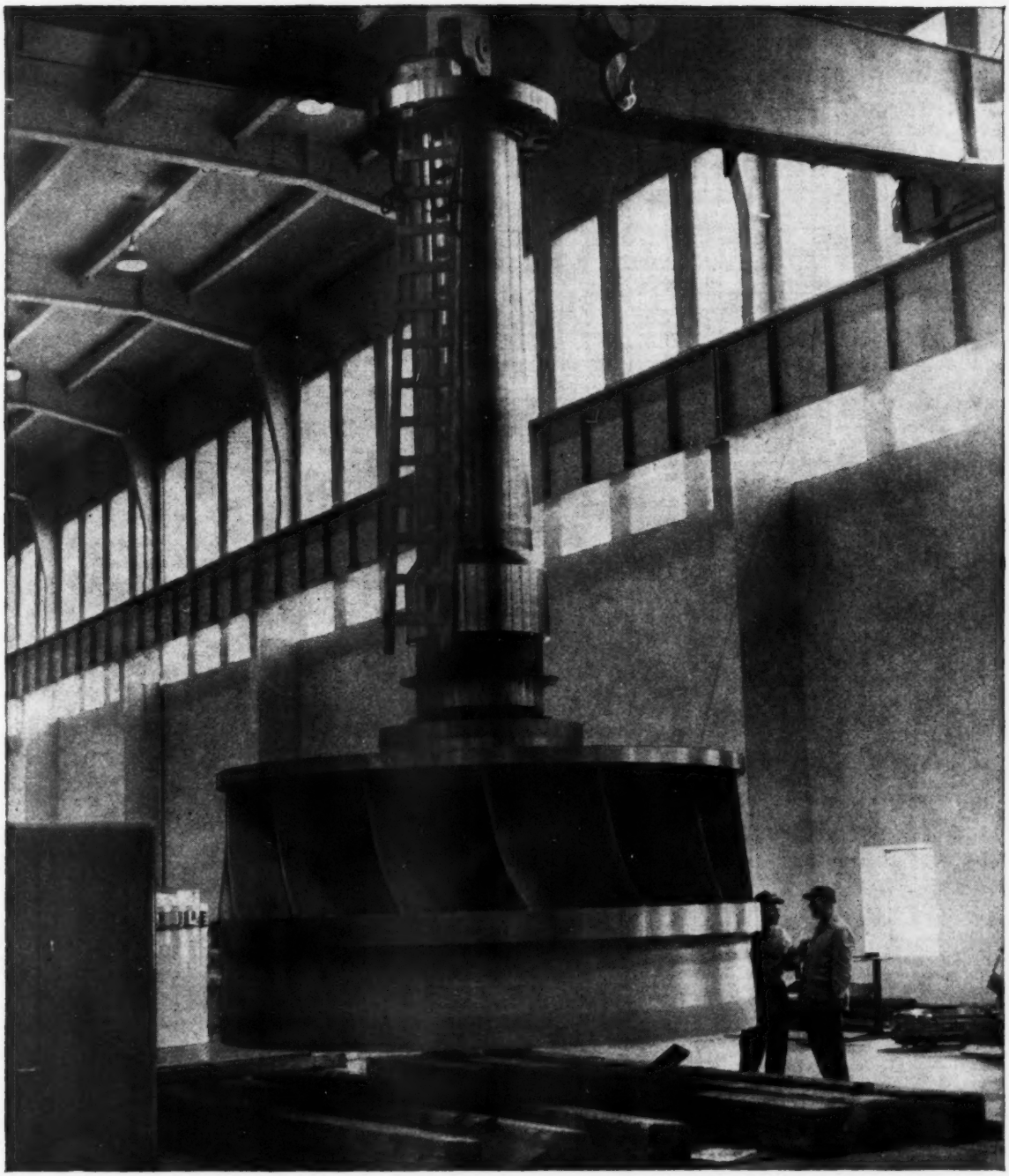


DE LAVAL

SKF Ball Bearing Co. Private Ltd.

De Laval Industrial Separator Division

P. O. Box 71, Bombay 1.



SIXTEEN 105,000 HP DOMINION FRANCIS TURBINES INSTALLED AT SIR ADAM BECK-NIAGARA GENERATING STATION No. 2 FOR THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

DOMINION ENGINEERING
COMPANY LIMITED
P.O. BOX 220, MONTREAL, CANADA, CABLE: DOMWORKS

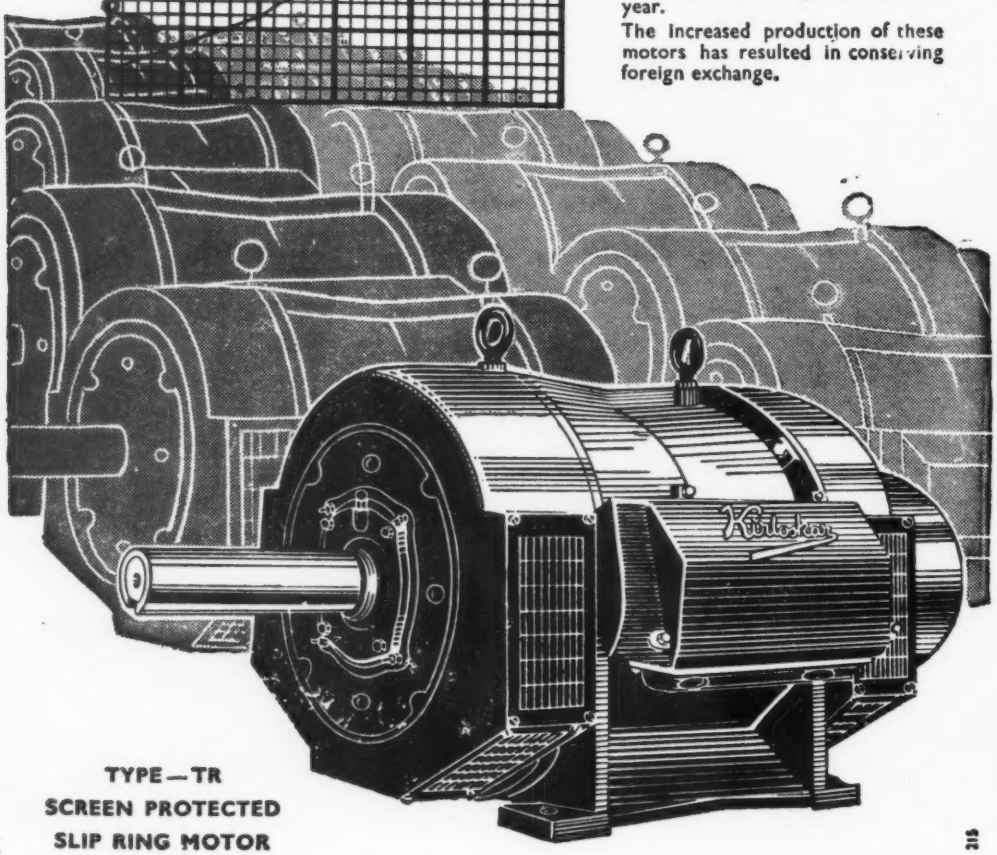
REPRESENTED IN INDIA BY
THE CROMPTON ENGINEERING CO.
(MADRAS) PRIVATE LTD.,
P.O. BOX 205, MADRAS, INDIA

PLANNED PRODUCTION

With the increased Industrialisation in the Country, the demand for Electric Motors has been continuously increasing, particularly in the range of 50 to 250 H. P.

To keep pace with this upward trend in demand, KIRLOSKAR ELECTRIC COMPANY have so planned their production that their output of motors in this range has also been increasing from year to year.

The increased production of these motors has resulted in conserving foreign exchange.



TYPE—TR
SCREEN PROTECTED
SLIP RING MOTOR

MANUFACTURED BY:
KIRLOSKAR
ELECTRIC CO. LTD.
BANGALORE-3

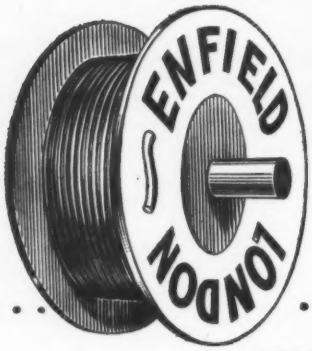
SOLE AGENTS:
PARRY & CO. LIMITED
P. O. Box No. 12, Madras-1
P.O. Box No. 506, Bombay 1
P.O. Box No. 208, Calcutta-1
P. O. Box No. 172, New Delhi

PENSTOCKS, PRESSURE SHAFT LININGS FOR ALL WORKING PRESSURES

GIOVANOLA

Monthey - Switzerland

ENFIELD CABLES



Paper Insulated Cables · Rubber Insulated Cables and Flexibles. Signalling and Telephone Cables. Mining Cables · High Conductivity Electrolytic Soft Copper Wires and Strips · Overhead Line Equipment. Joint Boxes and Jointing Material, Feeder Pillars · Grid Suspension Wiring System and Special Cables to Government Specifications.

Enfield

ENFIELD CABLES LTD., LONDON

Agents in India :

PHILIPS

PHILIPS INDIA LIMITED

Calcutta . Bombay . Delhi . Madras

Patna . Kanpur . Lucknow . Bangalore

P 90 R

Fabrication and Erection of complete

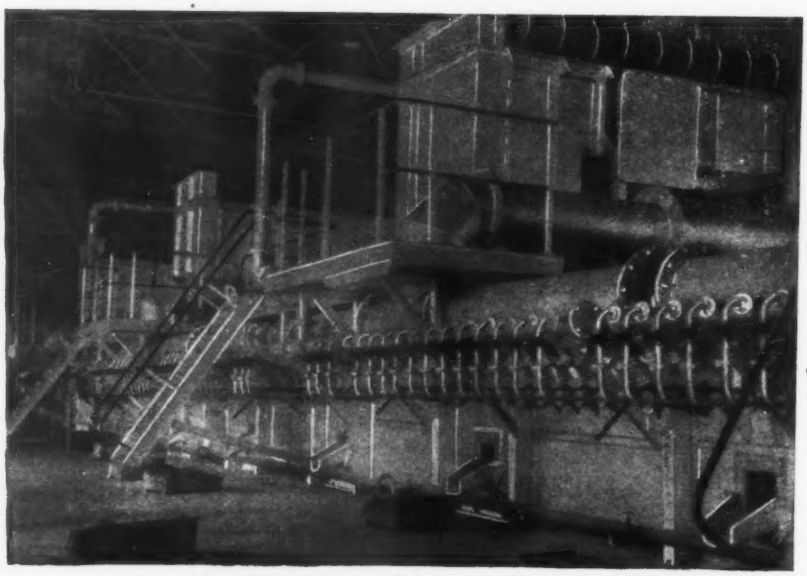
Pipework installations

for Steam, Gas, Compressed Air, Fuel Oil etc.

Coils for Refrigeration and other industrial uses

Light Structures of Tubular construction.

Water Well Casing.



Pipework installation on Fretz Moon Mill, Indian Tube Company (1953) Limited, Jamshedpur.

STEWARTS AND LLOYDS OF INDIA PRIVATE LIMITED

HEAD OFFICE : 41, CHOWRINGHEE ROAD P O BOX 270, CALCUTTA
TELEPHONE . 44-5224 (7 lines) and 44-1461

WORKS : 39, HIDE ROAD, KIDDERPORE, CALCUTTA
TELEPHONE : 45-3515 (3 lines)

SLF—35/56

Sangamo Weston Instruments

SANGAMO WESTON

Time Switches

Electricity Meters

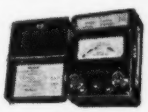
Thermometry

Panel and Switchboard Instruments

Laboratory Standards

Portable Instruments

Weston Standard Cells



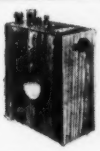
All-purpose Test Instruments

Moving Coil Relays

Aircraft Instruments

Photo-Electric Cells

Illumination Meters



Current Transformers

Electronic Measuring Aids

SANGAMO WESTON LTD., England

Distributors:

MOTWANE PRIVATE LIMITED

Incorporating:

EASTERN ELECTRIC & ENGINEERING COMPANY PRIVATE LIMITED

and

CHICAGO TELEPHONE & RADIO COMPANY PRIVATE LIMITED

1909 FIFTY YEARS SERVICE 1959

Electrical, Mechanical & Electronic Engineers and Contractors

127 Mahatma Gandhi Road, Post Box No. 1312, Bombay-1. Phone: 252337 (3 lines) Grams: CHIPHONE' all offices

Branches at: Calcutta, Lucknow, New Delhi, Madras, Bangalore and Secunderabad

SISTA'S-EE-48

young Rajendra Kumar and his colleagues are being trained for Durgapur steelworks

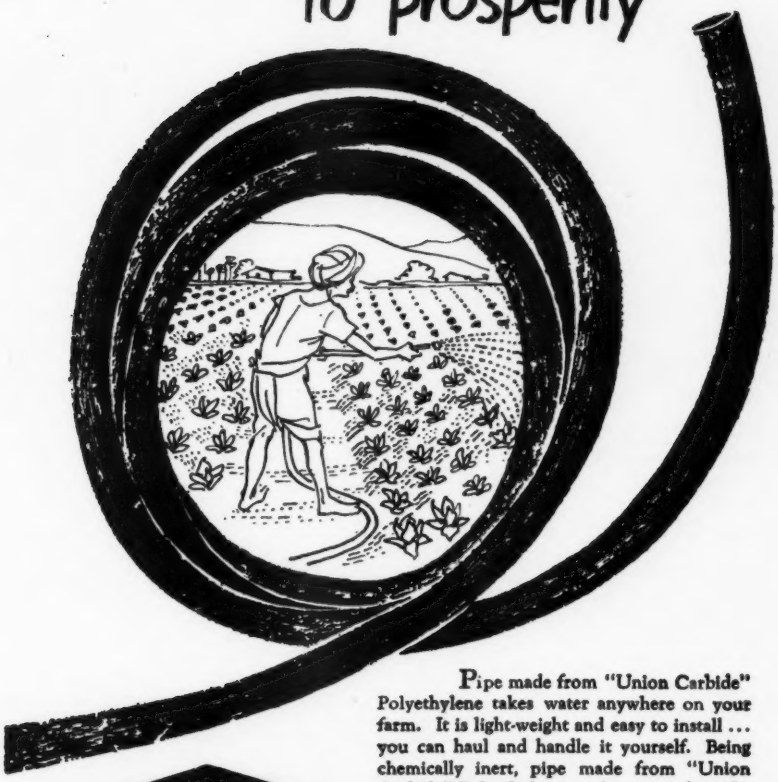
Twenty-three year old Rajendra Kumar Bhandari is a long way away from his home in New Delhi. He is in the U. K. at the Abbey Melting Shop of the Steel Company of Wales, taking drilled samples of metal from the ladle trunnion and casting.

Rajendra is one of the 300 young trainees who are at present taking specialised courses in various steel factories in the U. K. Upon completion of their training, the Indian technicians will come back to India, fully equipped to shoulder their responsibilities in the steelworks at Durgapur. In addition to technicians, ISCON is also helping to train up managerial personnel, who are given advanced management courses in the U. K. before they assume their positions at Durgapur.

ISCON

INDIAN STEELWORKS CONSTRUCTION CO. LTD.
Davy and United Engineering Limited. Head Wrightson & Company Ltd. Simon-Carves Ltd. The Wellman Smith Owen Eng. Corp. Ltd. The Cementation Company Ltd. British Thomson-Houston Co. Ltd. The English Electric Co. Ltd. The General Electric Co. Limited. Metropolitan-Vickers Electrical Export Co. Ltd. Sir William Arrol & Company Ltd. Cleveland Bridge & Engineering Co. Ltd. Dorman Long (Bridge & Engineering) Ltd. Joseph Parks & Son Ltd. Iscon Cable Group (Siemens Edison Swan Ltd. and Pirelli General Cable Works Ltd.)
BRITISH COMPANIES WORKING FOR INDIA

pipeline to prosperity



Pipe made from "Union Carbide" Polyethylene takes water anywhere on your farm. It is light-weight and easy to install ... you can haul and handle it yourself. Being chemically inert, pipe made from "Union Carbide" Polyethylene won't rust, scale or be affected by soil acids.

Write to us and we shall be happy to place you in touch with manufacturers of pipe made from "Union Carbide" Polyethylene.

National Carbon Company (India) Limited will soon manufacture Polyethylene at Trombay Island, Bombay.

UNION CARBIDE
TRADE MARK
Polyethylene

INDUSTRIAL PRODUCTS DIVISION
NATIONAL CARBON COMPANY (INDIA) LTD.
BOMBAY • CALCUTTA • DELHI • MADRAS

The term UNION CARBIDE is a registered trade mark of Union Carbide Corporation, U.S.A.

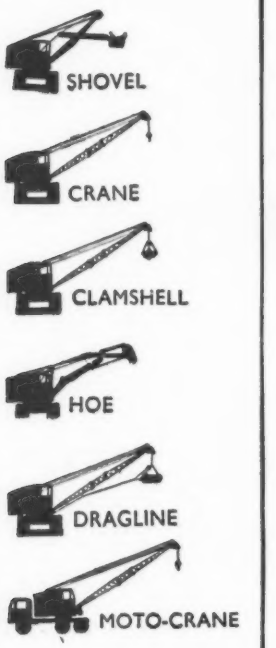
NCC 3634

LORAIN

SHOVEL-CRANE EQUIPMENT

for every job need

With a total of 134 different combinations, there is a Lorain shovel-crane equipment, on crawler or rubber-tyre mounting, for practically every job need. Shovel capacities range from ½ to 2½ yards and crane capacities from 6 to 75 tons.



EXCLUSIVE LORAIN FEATURES

2-Lever "Joy Stick" Power Controls

This type of "Joy Stick" controls power-actuates all turntable friction clutches for easier, faster, simpler operation. Using only two levers, operator fatigue is reduced and production increased.

"Shear-Ball" Mounting

It gives "ball bearing" rock-steady swing and completely eliminates centre pin and nut, centering gudgeon, hook or top rollers and exposed roller path with their attendant wear, need of adjustment and maintenance.

Ask Jacks about it

William Jacks & Co. Ltd.

(Incorporated in England. Liability of Members Limited)

CALCUTTA BOMBAY MADRAS NEW DELHI

WJC-287 A

INDIAN JOURNAL OF POWER AND RIVER VALLEY DEVELOPMENT

A MONTHLY DEVOTED TO DEVELOPMENT OF POWER & WATER RESOURCES IN ASIA

Editor: K. K. Sinha — P. K. Menon: Mg. Editor

VOL. IX — **NOVEMBER 1959** — **NO. 11**

DVC SPECIAL NUMBER

Issued on the occasion of
the inauguration of the PANCHET HILL PROJECT by the Prime Minister of India.

CONTENTS

INTRODUCTION	... ...	1
THE DAMODAR VALLEY CORPORATION—A SURVEY	*by U. K. Ghosal* ...	3
MAN AND MACHINE	*„ K. L. Dutta* ...	5
CONSTRUCTION OF PANCHET HILL PROJECT ...	*„ A. M. Komora* ...	7
DVC PROJECTS—SOME THOUGHTS AND REFLECTIONS	*„ B. Parthasarathy* ...	9
FROM A RIVER OF SORROW TO A RIVER OF HOPE	*„ M. K. Ghosh* ...	11
DESIGN OF PANCHET HILL DAM AND POWER HOUSE	*„ N. M. Chakravarty* ...	15
PROBLEMS OF THE DAMODAR VALLEY AND THE ASPECTS UNDER DEVELOPMENT ...	*„ N. S. Iyengar*	24
INSPECTION AND QUALITY CONTROL IN PANCHET DAM CONSTRUCTION	*„ B. B. Chatterjee and S. R. S. Rao*	26
POWER DEVELOPMENT OF THE DVC	*„ S. Bose*	29
PANCHET HILL HYDRO-ELECTRIC POWER STATION	*„ S. B. Deb*	34
SHORTAGE OF POWER IN DAMODAR VALLEY AND OPERATION OF THE DVC SYSTEM ...	*„ B. N. Banerjee* ...	43
IRRIGATION POTENTIAL OF DVC PROJECT AND ITS PROBLEMS	*„ S. R. Ghose*	47
NAVIGATION CANAL SCHEME	*„ A. K. Sen Gupta* ...	51
MODIFIED BUTTERFLY TYPE UNDER-SLUICE GATE AS ADOPTED IN TWO OF THE DVC DAMS ...	*„ S. S. Rao*	52
SELECTION OF EARTH-MOVING EQUIPMENT ...	*„ S. S. Pillai*	54
DRILLING AND GROUTING IN THE UNDERGROUND POWER HOUSE AT MAITHON	*„ A. C. Das Gupta and M. L. Subba Rao* ...	59
PROBLEMS OF CANAL EXCAVATION IN DVC ...	*„ Ram Sarup*	65
OUR CONTRIBUTORS	... ...	67

Illustrations in this issue with the kind cooperation of the Information Department of the DVC
Cover Photo: G. Balan

Editorial and Managerial Offices

6/2, MADAN STREET, CALCUTTA-13. PHONES: 23-1765 & 23-5855. GRAMS: TEKJOURN

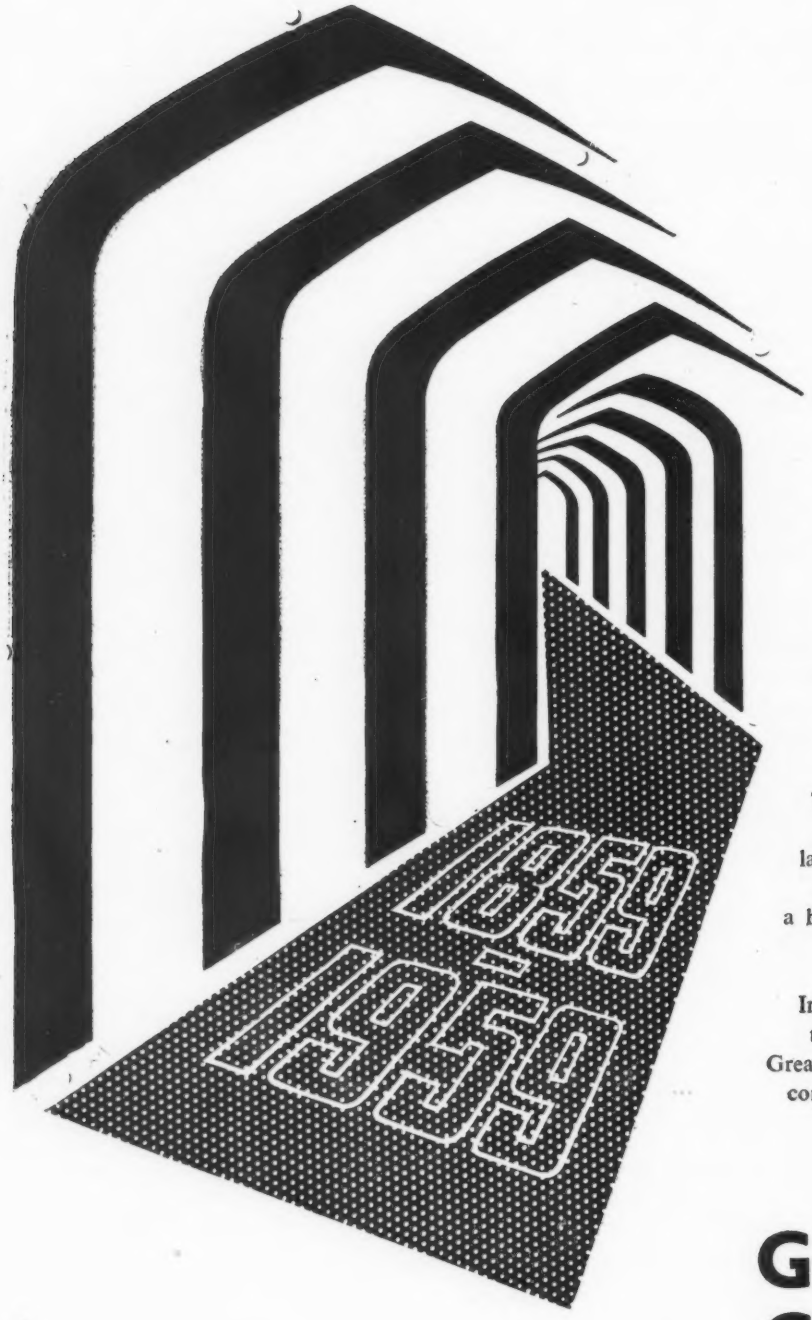
Manager: B. Bhattacharya

Bombay office
41, Hamam Street
Bombay-1
Phone: 252119

German Representatives
Linder Presse Union G.M.B.H.
Frankfurt/Main, Wittelsbacher Allee 60
W. Germany.

London Representatives
Walter Judd Ltd.
47, Gresham Street
London E.C. 2

Annual Subscription: Rs. 20, £2 or $6.00. *Single copy: monthly issue* Rs. 2
This issue Rs. 7.50 nP. *Back issues at double rates*



A Century of Progress...

The passage of time has shown that the foundation laid by James Greaves and his partner George Cotton a hundred years ago was well and truly laid.

In this hundredth year of their foundation the House of Greaves represents a happy combination of Indo-British cooperation.

GREAVES COTTON

BOMBAY • CALCUTTA • NEW DELHI • MADRAS • BANGALORE • AHMEDABAD • KANPUR • COIMBATORE • RANCHI

Ajanta GC/59-50

INTRODUCTION

With the completion of the Panchet Hill Dam, the DVC completes its Stage I programme as contemplated initially. Four dams—Tilaiya, Konar, Maithon and Panchet Hill—the Bokaro Thermal Power Station and the Durgapur Barrage have now come into full operation and thus a hectic and dynamic chapter beginning with 1948 has come to a close, as a new one is already emerging into relief. Who can recognise the old valley now? It has by now become a major centre of industrial activity in the country and is assuming ever greater importance with every year passing.

How has this come to pass? It was, paradoxically enough, the tragic and devastating floods of the Damodar in 1943 that compelled man to think constructively and, with the inspiring example of the TVA to guide, a multipurpose scheme of unified control and development was drawn up. It took ten long years of planning and hard work to realise into concrete shape that was visualised on the drawing board. The Damodar Valley Corporation, it is worthwhile remembering, started from scratch and now here is something that the country can be proud of. Proud not only of the dams and power houses, but also of the group of trained engineers and technicians who built these and are now confident to take up any such responsibility with competence. Mr. Komora, the Chief Engineer of the DVC who retired after a very creditable record of service, had reason to be proud when he said "Indian engineers are second to none" and by way of a parting advice remarked, "It would be wise for the Government to transfer this group, intact in so far as possible, on to a new project". This is an aspect which we would do well to consider while there is yet time. Architects of new India are no less important than its architecture which they have helped to create!

Flood control was one of the major objectives of the Damodar Valley Scheme. Now that the four dams have been built, time is ripe to consider whether all this effort has been worthwhile. But it should also be remembered that the Damodar scheme consisted of, not four, but seven dams. It is therefore but natural that given a major flood discharge, these four dams cannot control the floods completely; they can only moderate it. To that extent facts have fully justified their existence both in 1956 as well as in 1959. If flood control still remains a major purpose—and we believe it would be more so in view of the increased development in the lower valley compared to a decade back,—is there any other effective way out except the construction of the remaining dams proposed upstream?

Apart from the question of flood control, the demand for water for industrial and municipal purposes all the year round is increasing so fast that already shortage is being experienced. How else can this essential requirement for development of the area be met except by creating new reservoirs?

But it is also true that this programme of dam construction should be viewed in terms of the larger perspective. The problem has been admirably posed by Dr. N. K. Bose in our journal some time back (April, 1958). Possibly these man-made structures across the rivers are creating problems of a greater magnitude than our myopic

vision rivetted to immediate interests can perceive. It is of utmost importance that we work in harmony with nature rather than struggle against it, and still we will have a lot to do. We are particularly referring to the twin task of arresting soil erosion in the upper catchment and of flushing the river channel in the lower valley. Fortunately these problems are slowly dawning upon our planners and specialists. But as yet the impact of the task has not been striking enough to make them move in a big way.

The floods this year in the lower valley, when all the four dams were under operation, seem to have disillusioned a section of the public as regards the utility of these dams. As we have already pointed out, to some extent expectation was misplaced, as it was beyond the capacity of these dams together to control the record floods, due to unusually heavy rainfall both in the upper and the lower valley. But the facts of the specific situation will convince any detached observer that had the dams not been there the devastation would have been much more calamitious.

There is however an important lesson to be learnt from the experience of unified operation of these dams on this crucial occasion. It is that unless there is only *one single agency* aided with the latest techniques of receiving quick information regarding rainfall and run-off data throughout the entire region, it is not possible to regulate the gates of the dams intelligently to obtain the most optimum results. The present position in this respect is that the Water Controller is now dependent on most antiquated and undependable means of collecting and communicating information and that also through numerous agencies and authorities. Where minutes matter, hours and even days pass by without a ripple of urgency.

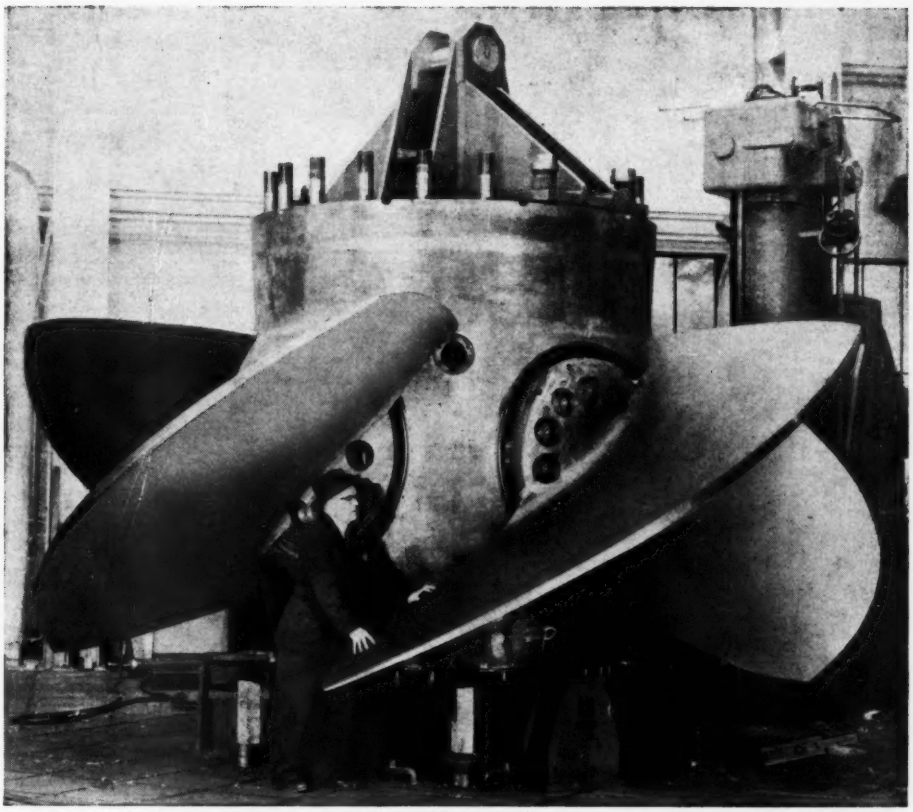
And it is also a moot point to consider whether the narrow and limited jurisdiction of the DVC in the lower valley is consistent with the flood control problem in the entire region covering several rivers other than the Damodar or whether it would not be better to have a wider operational control by a single agency.

There was a time when many felt that DVC power was surplus. But the true position is quite the reverse today. To date, the average load factor of the DVC power system is as high as 85%, the peak figures being considerably higher. The machines are overworked and adequate opportunity is not available for their servicing and overhaul even once a year. While new and larger thermal power stations are under erection—Durgapur and Chandrapura—it is obvious that the growth of demand is outpacing all efforts at supply. It has lept to ten times in five years instead of the normal pace of doubling. While the demand in 1960 would be 396 mW, the firm installed capacity would be no more than 209mW; by 1963 the corresponding figures would be 742 and 477 and by 1966, 1195 and 477. Thus here is another problem of growth that the country has to tackle. Hydro-resources in the region are limited as well as suffer from limitations; coal is plentiful. Uranium-Thorium ore has also been found in considerable quantity. Given intelligent perspective planning right from now, it should not be difficult to arrive at a concrete plan of development of power for not only the DVC area but the entire eastern region.

Thus while it appears that a phase of activity has ended, another has already begun. There is hardly time to stop and disperse and begin all over again. Indeed it would be so much waste of time. As we look back to a vigorous and enriching past, let us get the inspiration and enthusiasm to go to work for today and for tomorrow.

NOHAB turbine for PANCHET HILL

Runner for The Panchet Hill Power Station. Runner diameter 5.4 m. (17 ft. 8 in)



Specifications of large water turbines already delivered, or under delivery by NOHAB

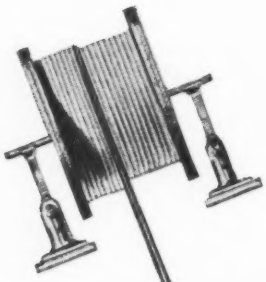
Power station	Number and type of turbine	Head ft.	Output per turbine, h.p.	Speed r.p.m.	
Stornorrfors, Sweden In service 1959	3 Francis	239.5	178,120	125	Guaranteed output at 246 ft., 200,000 h.p. The most powerful turbines in the world.
Lasele, Sweden In service 1956	2 Kaplan	170.6	87,200	150	This is the highest head for which a Kaplan has been installed in Sweden.
Porsi, Sweden In service 1960	2 Kaplan	118.0	131,000	115	These will be the most powerful Kaplans in Sweden.
Furnas, Brazil In service 1962	4 Francis	308.0	230,000	150	One of the most powerful turbines in the world.
Panchet Hill, India In service 1958	1 Kaplan	81.0	56,000	125	India's largest Kaplan, in output as well as dimensions.
Rincón de Baygorria, Uruguay In service 1959	3 Kaplan	48.2	49,500	79	With regard to dimensions, South America's largest turbines.

NOHAB

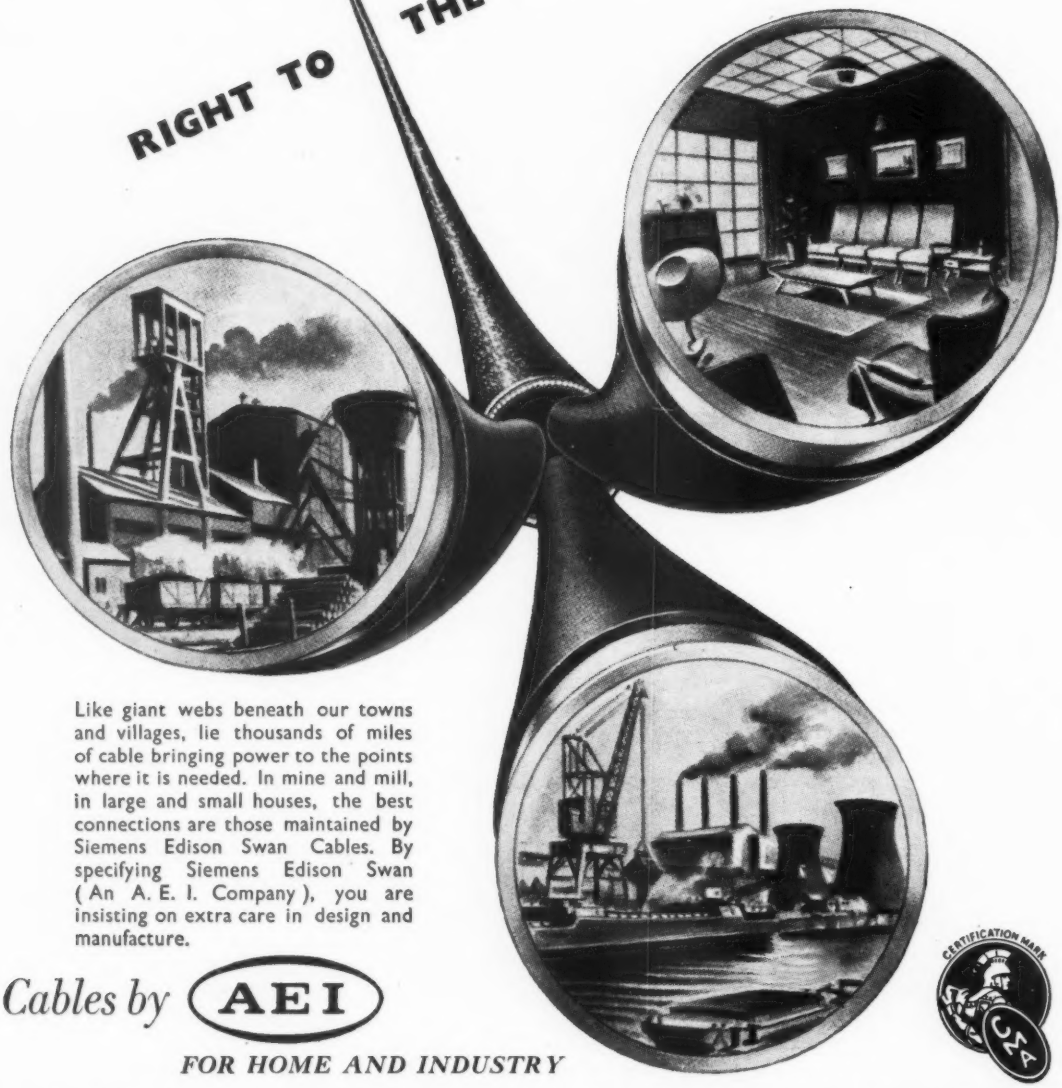
NYDQVIST & HOLM AKTIEBOLAG

TROLLHÄTTAN SWEDEN

Cables: NOHAB Telex: 5284 Telephone: 18000



RIGHT TO THE CORE OF THE MATTER . . .



Like giant webs beneath our towns and villages, lie thousands of miles of cable bringing power to the points where it is needed. In mine and mill, in large and small houses, the best connections are those maintained by Siemens Edison Swan Cables. By specifying Siemens Edison Swan (An A. E. I. Company), you are insisting on extra care in design and manufacture.

Cables by **AEI**

FOR HOME AND INDUSTRY

ASSOCIATED ELECTRICAL INDUSTRIES (INDIA) PRIVATE LIMITED.

Head Office : Crown House, 6, Mission Row, Calcutta.

Branches at : BOMBAY, NEW DELHI, MADRAS, BANGALORE, COIMBATORE, NAGPUR.

AIC-158 A

The Damodar Valley Corporation —A Survey

U. K. GHOSAL, I.C.S.,
General Manager & Secretary,
DVC

THE 6th of December, 1959 marks the conclusion of one clear stage during the life of the DVC, and at this point of time it is salutary that those who belong to it or are interested in it should take a look behind. It is inevitable that the rush of current events would tend to blur even fairly recent history—to the detriment of the Corporation understanding its own role and the country in general ascribing to it targets which it either never set before itself or had to moderate by reason of facts beyond its control. While the impetus to the formulation of the Damodar Valley Project was incontestably provided by the serious floods of 1943, it is equally a fact that the Project was conceived from its very inception as a multi-purpose one. It is not merely that the DVC Act defines its three main objects to be flood control, irrigation and power, and adds to them subsidiary objects like promotion of navigation, soil conservation, afforestation, research and experimentation, etc. The debates in the Constituent Assembly (Legislative) envisaged—on the part of the entire House and not merely the Treasury Benches—the different fields in which the Corporation was to operate. Furthermore, every single broad undertaking of the Corporation was subjected to scrutiny by the three Participating Governments, in the Government of India and the Governments of Bihar and West Bengal, and it would be an incorrect presumption that in taking up its various activities from time to time, or even in the relative weight given to each, the Corporation acted without the full knowledge and assent of the three Governments.

Leaving aside the subsidiary objects, the Corporation was required to satisfy certain expectations of its three 'share holders', and these included all the three main objects—control of the periodical flooding of the Lower Valley by the Damodar, supply of irrigation water to make up for the equally periodical deficiency in rainfall, and to generate and sell power to serve the needs of an area which was known to possess unlimited industrial potentiality. If the generation and distribution of power had been the sole or even the principal function of the Corporation, its activities would have taken a shape very different from the actual picture. Similarly, if the object had been either flood control or irrigation, to the exclusion of other aims, the projects that the Corporation initiated and executed would have been totally dissimilar. In the spate of understandable criticism that arose after the Lower Valley floods of October last it was overlooked that the Corporation was also committed to supply water for irrigation and that this liability necessarily imposes a restriction upon the extent to which it could deplete storage to provide for an unpredictable quantity of rainfall in the catchment areas above the dams. Among the numerous special articles that appeared in newspapers and journals after the floods only one appears to have drawn attention to the blame that would rightfully have been laid at the Corporation's door if it failed to supply irrigation water and tried to defend itself by saying that it had failed to foresee that an amount of rainfall that was anticipated would not in fact take place.

Let us take a quick glance at the history of the DVC and then turn to its performance. Compared with other big projects, the Damodar Valley Project took shape with an unusual amount of speed and unanimity of support. The passing of the TVA enactment was preceded by about forty years of controversy, and it is a matter of speculation whether it would have been passed at all without the great personal standing of the late President Roosevelt. The Hyderabad and the Madras Governments took more than twenty years to settle their difference over the construction of the Tungabhadra dam, and even then it was constructed with two sets of builders—each Government building the portion in its own territory. The Bhakra Nangal Project was on the anvil for forty years before it was given a working shape. The work on the Krishnarajsagar Dam remained in suspension for ten years after partial execution. In contrast, the decision to harness the Damodar-Barakar System was taken in 1944, the preliminary engineering plan was ready in August, 1945, and the Participating Governments hammered out all conflicts of interests and settled the financial commitments—including the constitution of an autonomous Corporation—by the middle of 1947. The DVC Bill was presented to the Constituent Assembly (Legislative) in December, 1957 and passed in February, 1948. The Project caught the imagination of the whole House. The enormous difficulties that the Corporation would have to face were foreshadowed by a few Members. One of them drew attention to the fact that the normal land acquisition procedure is dilatory and suggested that special provision should be made in this regard. Another Member referred to the shortage of scientific and technical personnel capable of undertaking this type of assignment

which was unprecedented in India. A third Member referred in his speech to difficulties of another kind when he said "We are not a disciplined nation; our Government is not disciplined. We are all indisciplined. We are following theories and dreams. Whatever forecasts the Hon'ble Minister's experts may make, he must consider this human factor of ourselves. We have a certain human way of living and we cannot suddenly grasp the high sounding ideas—the machine ideas—which the TVA or the American people practise." The experience of the past eleven years has shown that if the apprehensions regarding India's inability to 'grasp the high sounding ideas' were exaggerated, the other difficulties did not by any means suffer from understatement.

The Corporation was created on the 7th July, 1948 and with a nucleus of energetic and enthusiastic engineers entered upon its gigantic adventure. Conditions were such as to test both the zeal and the ability of the team to the full. Machines had to be imported, and when they arrived there were not enough operators and maintenance crew. The subordinate engineering, finance and accounts personnel were not familiar with the problems of mechanised construction and there was hardly any one in the country capable of training them. The training had to come through actual experience, and a price had to be paid for this. There was no organisation in the country at that time capable of undertaking design work for dams. It took two and half years to find a Chief Engineer with practical experience of dam building and large scale mechanised construction. An American firm had to be appointed as the Construction and Consulting Engineers for the Bokaro Thermal Power Station while another firm was appointed as Consulting Engineers for the Maithon Dam and later for the Panchet Hill Dam. Procurement of equipment and spares continued to pose difficult problems for many years until a body of experience was painfully built up. Available hydrological and meteorological data were inadequate and the Corporation had to set up an organisation of its own. Such geological data as were available were also found at different stages of construction to have been insufficient, requiring modification of designs and working schedule. Essential materials such as cement and steel were in short supply for the major part of this period. Equipment, whether for earthmoving or for power stations and transmission lines, had to be procured mostly by import, and this led to inevitable delays in delivery and shipment. Political uncertainties (such as those created by the Korean War and the Suez Blockade), natural calamities like floods, procedural delays (for example, over land acquisition) and even shortage of reliable contractors—all these and many more problems had to be met and overcome as they occurred. That this was done is in itself a tribute to the capacity of our people to face unprecedented situations, with no benefits of past experience, and to find solutions for problems that, half a generation earlier, would have resulted in complete bafflement. It is appropriate, at this point, to remember with appreciation the invaluable guidance that the technical personnel of the Corporation received from its first Chief Engineer Mr. A. M. Komora and its various foreign Consultants. It is not with immodesty but with justifiable pride that one recalls Mr. Komora's opinion that the team of engineers that he had worked with was 'second to none' in the world.

With the completion of the first phase of its activities, the Corporation now has four multi-purpose dams at Tilaiya, Konar, Maithon and Panchet Hill and a thermal power station at Bokaro (installed capacity 150 mW), and associated transmission lines. In addition it has constructed the barrage across the Damodar at Durgapur and approximately 1500 miles of irrigation canals with hundreds of structures like Regulators, Locks, Syphons, Superpassage, etc. An extension of this phase—which is well on the way to completion—involves the addition of a new thermal unit at Bokaro of the capacity of 75 mW, the installing of two thermal units (total 150 mW) at Oariya near Durgapur, additional transmission lines and a number of substations for supplying power to the electric traction system of the Railways. Sanction has been received for installation of two more thermal units at Chandrapura (Distt: Hazaribagh) each with a capacity of 125 mW. There was a time—not long ago—when doubts were expressed, even at a high level, as to the ability of the Corporation to find consumers for a considerably more modest quantum of power than what is now being generated. In actual fact the present demand is far in excess of the available supply, and repeated load surveys have confirmed that more power must be made available to enable full development of the industrial potentialities of the region. If and when this augmentation is sanctioned it can come only from thermal units (with the exception of relatively small additional capacity at Panchet Hill and at Konar), which, in view of abundant local supply of cheap coal, would more than justify the investment.

As regards irrigation, in 1958 the Corporation, with a partially complete canal system was able to supply sufficient water to meet the requirements of a little under five lakh acres during the kharif season. In 1959 the Corporation placed itself in a position to raise this figure to over 9 lakh acres.

The aspect of flood control has acquired topical interest because of the floods of October 1959. A point that unfortunately appears to have received insufficient appreciation is the physical circumstances. The original plan contemplated the construction of eight dams, it was calculated that when all these were built —the stress being on the word 'when'—it would be possiple to regulate an inflow of the order of one million cusecs above the dams to 250,000 cusecs i.e. to less

(Continued on page 6)

Around the clock... Across the country...

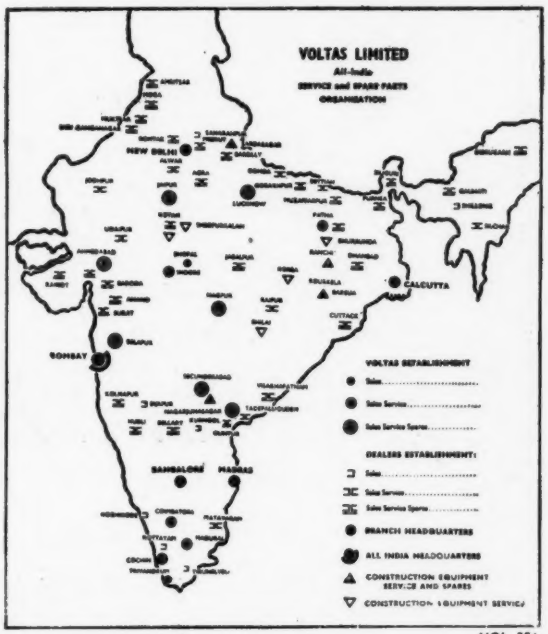
Mack Dumpers

backed by

VOLTAS SERVICE

MACKS — the FIRST CHOICE all over the world for stripping, mining and quarry service — are speeding up progress on numerous projects in India by working round the clock. A NEW and significant addition to the wide range of rugged and sturdy MACK End and Bottom Dumpers is the Model LYSW End Dumper with an 80,000-lb. payload capacity! This JOB-PROVEN unit is designed and built to haul the toughest load at the lowest cost under the most adverse conditions.

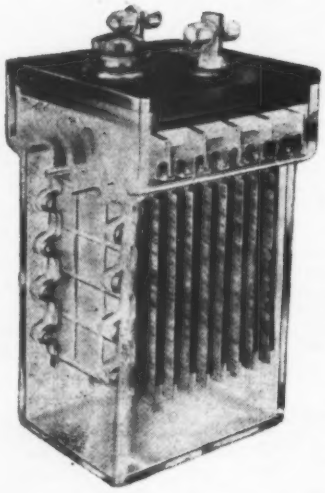
MACKS in India are backed by Voltas' nation-wide Service and Spare Parts Organisation.



VOLTAS **VOLTAS LIMITED**
Construction Equipment Department

Bombay - Calcutta - Madras - New Delhi - Bangalore
Lucknow - Ahmedabad - Secunderabad - Nagpur - Patna

PRITCHETT & GOLD BATTERIES (EASTERN) LTD.



9, Forbes Street, BOMBAY 1

31, Chittaranjan Avenue, CALCUTTA 12

For all types of

LEAD ACID

AND

ALKALINE

ACCUMULATORS

C. W. & P. C. SPECIAL NUMBER

of

INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

Exclusive contributions from Sarvasree M. Hayath, S. S. Kumar, Yadav Mohan, R. C. Hoon, V. Venugopalan, S. L. Banerjea, R. D. Dhir, A. Shankaran, P. R. Ahuja, S. Raghavachari, K. B. Khushlani, J. E. Vaz., K. C. Khatri and others.

Price : Rs. 7.50 (postage extra)

Book your orders with :

BOOKS & JOURNALS PRIVATE LTD.

6/2, MADAN STREET, CALCUTTA-13

Man and Machine

by K. L. DUTTA
Deputy Secretary, DVC

THE Panchet Hill Dam and the Hydro Electric Plant have at last come up in spite of difficulties and obstacles too numerous to be described in this short note. It is the biggest of the four dams built by the Corporation. It is 134′ high from the lowest River bed level (167′ from the lowest foundation level) and 22,155′ long. The volume of the concrete dam is 3.4 lakh cu.yds. while that of the Earth dam is 69.30 lakh cu.yds. The Reservoir covers an area of 59 sq. miles and the storage capacity is 12.14 lakh aft. at the top of gates and 13.65 lakhs aft. at the highest flood level. The present installed capacity of the Hydro Plant is 40 mW and foundation has been laid for an additional unit of 40 mW subject to availability of water. The dam successfully held the flood of September '58—a flood bigger than that of 1943—although the main gates were yet to be erected. The Hydro Plant came into operation in September '59. It embodies the result of sustained efforts of a body of determined people who threw themselves heart and soul into the job and worked day and night for six years in spite of difficulties and privations and under all climatic conditions. Our heart is full of admiration for all the thousands of people who worked for the Project and no less for the inhabitants of the 130 villages who surrendered their hearth and home in the interest of the nation.

This reminds one of man's eternal struggle against Nature from the day he was led to think of protection against wild beasts and hunger, heat and rain, storm and other elements of Nature. He invented stone implements to kill wild beasts and lived in caves on animal flesh but could not successfully contend against heat, rain, storm and other elements of Nature and resorted to a policy of appeasement by means of worship. Then comes in the conception of a Supernatural Entity presiding over all that man sees around and later, a new philosophy of life and a new pattern of human relations derived from the conception of a fundamental unity in creation whereby everything man sees around was considered as the manifestation of the Supreme Being.

Man is ever ambitious and could not stop at that. He thought of fighting Nature face to face so as to overcome the forces of nature obstructing the ways of man. He invented machines to substitute manual labour and to fight the enemy in war. Machine now thinks and works for man. Machine accomplishes things in an hour which human efforts could not do or could do in a month. Machine undertakes ploughing and harvesting; cooks for man, washes clothes and cleans the carpet; builds roads, bridges, canals, dams and barrages and last, though not the least, fights the enemy in war. The industrial revolution brought in its wake a new conception of "wealth" which by an imperceptible psychological process, gave rise to a new philosophy of life and a new pattern of human relations which are killing the soul in man and, today, threatens to wipe out the human race from the face of the earth.

India built massive and sky-high Temples and Palaces without Cranes, Concrete Mixers or Pile-driving machines and set up roads, bridges, canals and other utility structures without Shovels, Bull-dozers or Draglines. In the British period mechanical equipment were scarcely used for building dams, power houses, railways, canals and harbours but we have, since independence, been obliged to take to monster machines with a view to accomplishing certain development targets within a limited period. The speed and efficiency of machine methods have undoubtedly been very remarkable and we have learnt a new technique but the question is whether we are going to perpetuate this method in the country or to fix a deadline or restrict its use to selective spheres of human activity where human efforts fail.

The machine idea originated in Europe primarily from shortage of manpower which was found, not long after the Industrial Revolution, insufficient to cope with the pressure on their industrial plant which killed all the indigenous industries and flooded the Eastern countries with consumer goods. There are grounds to think that, with industrialisation in the Eastern countries, the present industrial edifice of Europe will crumble down and they will very soon have to face growing unemployment in their countries. In India the peasantry which constitute about 80% of the rural population have no work during 6 months of the year and machine methods have curtailed the scope for alternative employment during the period of recess. The weaver is starving while mill-owners are bungling with their products and the prices and making fabulous profits. The Stone-cutter and the Earth-worker, the village Blacksmith and the Carpenter have been displaced from their hereditary trade while the millioners are accumulating gold. These rural people engaged in small industries have been obliged to join the labour ranks of factories and workshops and to overcrowd cities while the resources of the Municipal Corporations are not sufficient to meet the civic needs of an ever-growing population in the city. Rural economy and rural social life have been completely disrupted and Government is spending crores of rupees for rural uplift without much success while vices pre-

valent in industrial areas are stimulating crime and social disorder in various forms which cannot be brought under control without a substantial increase in the strength of the Police forces.

The most disastrous effect of large-scale mechanisation has been the annihilation of the human soul and the disruption of human relations. A machine-man worships the machine rather than man. A man working the machine for some years forgets the genius of the man who invented it and gradually comes to think that the machine is more powerful than man and by a psycological process human relation, as we understand it, disappears and kills the initiative in the man. While in England, I had an occasion to visit a factory in Coventry accompanied by a friend and neighbour of mine who was an industrial economist by profession. We found one man boring holes in a thick steel plate and another man bending steel plates, a third man shifting the manufactured products merely by a pressure on the electrical button; yet a fourth man starting an engine by means of pulling a key. On enquiry we were told that they had been doing this job for the last 10 to 15 years. On our way back my friend suddenly said, "Look at the manner how machine is degenerating a people into a Nation of Assess." I looked at him and he continued saying that if a man merely presses the button for 20 to 30 years of his life not knowing why he was doing so, how the hole was being made and what his other colleagues were doing, he would himself eventually be a machine neither capable of thinking nor maintaining relations with his neighbours. This at once recalled to my mind the short story of Dr. Tagore in which he describes how machinery and machine age are swallowing and destroying everything that is human on Earth.

A man who has drunk a bottle of whisky is anxious to give up the habit while one who has just tasted it is anxious to see the day when he will be able to drink a bottle in one sitting. The present note of caution should, therefore, come from a much bigger person than I am just as a Field Marshal has offered to devote the rest of his life for the cause of disarmament while Prime Minister Kruschev has recently offered to throw all their deadly weapons into the ocean if other nations follow suit.

THE DAMODAR VALLEY CORPORATION—A SURVEY

(Continued from page 4)

than the bankful capacity of the Damodar, below Durgapur. The Participating Governments approved the construction of four dams in the first phase, and these four restricted the flood control capacity to an inflow of 650,000 cusecs. In September, 1958, the precipitation above the dams was roughly 665,000 cusecs, and the four dams (of which the one at Panchet was not complete at the time) succeeded in regulating the discharge to 205,000 cusecs. The river was able to drain away this volume without causing any inundation because the precipitation had been largely concentrated in the upper catchment. In October 1959, however, the Lower Valley was already inundated as a result of very heavy rainfall from the middle of September, so that when precipitation in the upper catchment made discharges from the dams unavoidable for reasons of safety, the total volume led to aggravation of the pre-existing floods. Even then, more than fifty percent of the inflow was held back by the four dams, without which the disaster in the Lower Valley would certainly have been of very much greater dimensions.

From what has been said above it is to be inferred that the Damodar Valley Corporation has, by and large, achieved what it had set out to do and—a point that would bear repetition—what the three Participating Governments required it to do. Undoubtedly there have been shortcomings, and if one could foresee lessons that can be learnt only from experience, the achievement would have been better. However, to the writer at least there does not seem to be any feasible alternative to paying for experience when personnel are new to a job, material is in short supply, basic data are incomplete, and funds are not unlimited. From the point of view of the nation the gaining of this experience can fairly be said to have been an investment, for to-day the Corporation and its technical personnel are in a position to undertake with self confidence any assignment that it may be called upon to undertake as part of the second phase of its work.

Construction of Panchet Hill Project

by A. M. KOMORA
Chief Engineer (Retired), DVC

PANCHET Hill Dam is the last of the four major dams to be constructed by the Damodar Valley Corporation, in the first phase development. The other three projects are Tilaiya, Konar and Maithon which are all completed and in operation.

Panchet Hill Dam is a composite earth-cum-concrete structure. The height of the dam above the river bed is 133 feet. The total length is 18000 feet. The volume of earthfill is 7,200,000 cubic yards and the concrete structure 420,000 cubic yards. The dam is located on the Damodar River, 3 miles upstream from the confluence of the Barakar with the Damodar river.

Five separate sites were investigated. Each of the first four sites presented problems in that they were crossed by deep fault zones. The final location is on a bend (of almost 90°) of the river. This offered several construction advantages. It was possible to excavate a diversion channel across the bend and to utilize the spoil in constructing a portion of the earth dam on the Damodar River bed. This was done in the first two working seasons (1952-53 and 1953-54). A steel sheet pile revetment was driven around the end of the earthfill to protect the earth dam from being scoured out during monsoon floods. This method of construction proved to be very successful. During high river flows the main current of the river swung to the right bank leaving the partially constructed earth dam intact.

The foundations of the concrete spillway were constructed prior to the 1955 monsoon. A diversion conduit was constructed in one of the lowest concrete blocks to bypass the ensuing dry season river flows. In November, 1955 the final closure of the main earth dam across the Damodar was made and the river was diverted through the diversion conduit in the concrete dam. From then on it was a race against time. The earth dam had to be constructed to a sufficient height to bypass an estimated construction flood of 350,000 cusecs through the diversion channel by June 15, 1956. Here, as in the case of Maithon, the upstream portion of the earth dam was constructed to a higher level than the balance of the structure as time did not permit placing the entire fill in the space of 7½ months. Actually the earth dam was constructed ten feet higher so that a flood of 450,000 cusecs could be bypassed. This was a wise precaution as a flood of 410,000 cusecs occurred in 1958 and it could just as well have happened in 1956.

The second critical phase of construction occurred in the 1957-58 working season. The two power house intake blocks had to be constructed from the rock foundations to a height sufficient to bypass the 1958 flood waters over the spillway blocks. The two intake blocks contain twentyeight foot diameter steel penstocks, intake gates, bulkhead gates, intake structures and trash racks. All of the steel structures and equipment except the intake gates were fabricated departmentally in the Maithon Workshop. All of this work was done in a space of eight months. As mentioned before a flood with a peak inflow of 410,000 cusecs (which was reduced to 180,000 cusecs passing Panchet) was successfully bypassed without causing any damage to the permanent structures.

The construction of Panchet was started with a few new earthmoving machines supplemented by used equipment from other projects. The small Tilaiya batching plant consisting of two 2-cubic yard mixers was utilized on the first stages of the concrete dam. Upon completion of Maithon, the entire concreting plant consisting of crushers, conveyors, screens, batching plant, cranes, etc., together with earthmoving equipment, was transferred to Panchet. This greatly expedited the work.

The entire work at Panchet has been done departmentally. It was evident that the quality of workmanship and speed of construction improved from project to project as the men gained added experience. As of today the construction organization at Panchet is equal to that of any contractor. It has taken eight years to weld this group into a smooth working team. It would be wise for the Government to transfer this group, intact in so far as possible, on to a new project. A certain price has been paid for training the men to do their various jobs. This training would pay dividends on another similar project.

Dodsal

PRIVATE LIMITED

Consulting engineers, erection and maintenance contractors and suppliers of equipment from the leading German manufacturers

AEG

FRANKFURT AND BERLIN
Electrical machinery and equipment

MANNESMANN A.G., DUSSELDORF
Tubes, penstocks, iron and steel products and tubemaking and finishing machinery

WALTHER & CIE, KOLN-DELLBRUCK
Steam boiler plants with accessories

A. FRIEDR, FLENDER & CO., BOCHOLT
Mechanical power transmission equipment

GUSTAV F. GERDTS, BREMEN
"GESTRA" steam traps and blow-off devices

WEISE & MONSKI, WEISE SOEHNE, BRUCHSAL
Pumps of all kinds

TELEFUNKEN, ULM/DONAU
Wireless transmitters, radar, and industrial electronics

OFU, Dusseldorf
Industrial furnaces of all kinds

These are only some of the manufacturers whose products are handled by Dodsal. Please contact any of our offices for more details.

DODSAL OFFICES

Head office: Mafatlal House, **Bombay-1**
Branches: United Commercial Bank Building, Parliament Street, **New Delhi**
33 Chittaranjan Avenue, **Calcutta-12** ✳ Erection site, **Rourkela**

SISTA'S.DL.33

The DVC Projects— Some Thoughts and Reflections

B. PARTHASARATHY,
Chief Engineer (Civil), DVC.

A tablet on the Eildon Dam in Victoria has the following legend:

"A TRIBUTE TO THE SKILL AND LABOUR OF THE MEN OF MANY OCCUPATIONS WHO MADE POSSIBLE THE BUILDING OF THIS GREAT DAM.

ENGINEERING IS THE ART OF ORGANISING AND DIRECTING MEN AND OF CONTROLLING THE FORCES AND MATERIALS OF NATURE FOR THE BENEFIT OF MANKIND."

Another such great project is the Panchet Hill Dam, the completion of which marks the attainment of the target of the first stage of constructions in the Damodar Valley. It is not yet known whether further work, as originally contemplated for the full development of the Valley, would be taken up at all. My purpose of writing this short article is to focus the attention on a major problem that we face and that is the future of the great organisation that we have built up over these eleven years since the inception of the Damodar Valley Corporation. Starting from scratch, we have built up inch by inch, brick by brick, this great edifice, comprising of activities in various spheres of the engineering and administrative fields that made up this huge construction organisation. Our organisation is essentially an engineering organisation and every one of us have been working with zeal and endeavour and with faith in our future. As a man, the engineer is much the same as any other man. He does not take up engineering and practise it because of the great opportunities it gives for public service, but he does so mainly because he likes it. It is a well known fact that the monetary rewards in engineering are not the same as in any other profession. Even so, men do not enter the engineering profession to attain a high social status, nor, as already said, does it offer much in the way of monetary reward. Still people go to it because they like it. The satisfaction that a true engineer derives from his work cannot be equalled by that of any other profession. The engineer constantly tries to improve and perfect upon his work and designs for the sake of work itself. He enjoys directing the force of nature to the use of mankind and takes pleasure in the beauty of a smooth working machine or a satisfying structure. Once he completes a work, he turns his attention to further efforts in "tests in which we seek to reconcile the unchanging laws of nature to the changing desires of man." He looks upon the works that he has created with his imagination and his hands, and he sees they are good, and, besides making sure that they are maintained properly, he is "content to leave to others the use and exploitation of the results of his efforts."

All this sounds very nice. However, in practice "we cannot help but be shocked at the waves of unemployment and human misery which come again and again and spread wider and wider to deny to the masses of men the benefits which so many believe to be within their reach."

This then is the main basic thought in my mind as I commence to write a few words for this article.

The Damodar Valley Project is essentially a River Valley Project and, as such, may be called a specialised line of engineering. This involves conservation and utilisation of water to the best interests of the community requiring construction of big Dams and Barrages, Power Stations for the generation of the hydro and thermal electricity, Canals for diverting the flowing waters into the fields for the production of food, utilising the flowing waters for inland navigation, using the large storages for the development of fish culture, besides numerous other items, like, soil conservation, afforestation, road and other building activities, water supply, sanitation, distribution of produced power and marketing thereof, etc. For each of these fields of activity, we have trained men from the topmost engineer down to the technician and labourer in the field and from the top administrator down to the assistant in the offices, each one an essential component of this great organisation.

While it may be said that the change from one project to another, so long as it involved similar work, would not present much of a problem, especially to the non-technical employee; for the Engineer and the Technician the case is different. He is, with the background of his theoretical knowledge and practical experience, specialised in certain specific categories of work and by giving him further opportunities, there is no doubt that the return would be far more than when he is pushed into a new field and has to start again from the beginning. I do not mean that the Engineer, who is trained in one field, cannot adopt himself to another so long as it is basically engineering—Civil, Mechanical or Electrical, as his qualification may be. In these days of specialization and the opportunities for doing similar work and the necessity of completing works in the quickest pos-

sible time, the utilisation of the right type of men is vitally important.

When a young Engineer has entered into a big project job and has worked with honesty, sincerity and zeal, he naturally looks forward to continuance of his activities and for the betterment of his status. On project jobs the main problem confronting the Engineer and the Technician is "what next". A person would give his very best to the job he is doing if he was mentally at peace having nothing to worry regarding his future to the betterment in his profession. If the constant thought of uncertainty of further employment on the completion of the job he is presently engaged on troubles him, it would be very unnatural to expect him to give his best in the work, much as he would like to.

Unlike the old days when generally technical men were flocking into the Government services, the position these days is different. There are plenty of opportunities for work, both in the public and private sectors, only, the prospect of continuity is not there in all cases. Lately, many public projects have been taken up or are about to be taken up and the problem confronting the authorities of these organisations is of recruitment of the right type of persons to man the numerous posts that they have. No organisation gives a guarantee of continuity of employment and only a contract service is offered. This is the root cause of the inability of the incumbent of a job to concentrate on the work he has, without having to think of other avenues of employment the moment he finishes his present assignment. This not only dislocates the work that the person is employed on, at the same time there is no guarantee that in the new job he would continue till that assignment was over because the factor of uncertainty in employment is repeating itself.

It is, therefore, of paramount importance for the Government to see that a solution is found for solving this ever-present uncertainty of employment. By a judicious phasing of the various projects in the country and a programmed recruitment, release and transfer of personnel, it is possible to minimise the disadvantages which the technical profession is facing today. As far as the River Valley Projects are concerned, I feel that the solution lies in the proper organisation and deployment of technical personnel. India being a vast country can be divided into a number of zones, each zone under one central authority, being responsible for the planning and execution of national projects. After satisfying the requirement of the zone concerned, it should be possible for the inter-change of men from zone to zone assuring ourselves that the best and most suitable men are available for the various projects and, as far as the technical personnel themselves are concerned, the question of continuity of employment would set at rest their minds and thereby create an atmosphere congenial to giving their best to the project to which they are attached. So far, I have only dealt with in general terms of the Engineer and Technician. While in the case of an Engineer, it may be possible for him to adjust himself to the various jobs even though they may not be of the same category, the position is different from the point of view of the Technician. Recently, large numbers of trained operators of heavy earth-moving equipment were rendered surplus and, because of the non-existence of immediate prospect of employment in a similar category, they have been forced to take up employment as Transport Drivers. This, to my mind, is wasting of precious talent and training. There was a time when we could not get suitable men to operate the big machines we acquired and having trained them and made them efficient operators, it is a pity that we are wasting them on jobs which do not require such specialization.

The Government is fully aware of these problems and, I am sure that, with a special effort it should be possible to build up a country-wide cadre which could be worked either on zonal or inter-zonal basis and thereby utilise to the best advantage to the nation the talent and experience of the trained personnel in the various national projects, like the Damodar Valley Corporation, which are completed or nearing completion.

NAVIGATION CANAL SCHEME

(Continued from page 51)

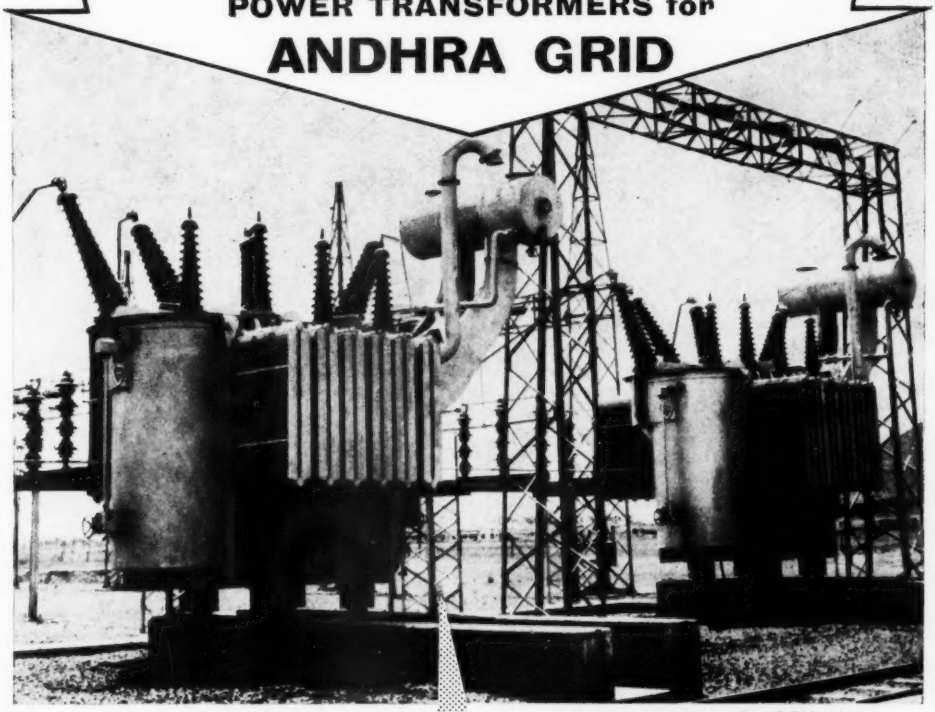
loading, locking, journeys inside the canal and Hooghly, waiting time and holidays.

While it is a fact that inland water transport is somewhat handicapped compared to other means of transport in the matter of route, which is generally somewhat circuitous particularly between Calcutta and Assam, the DVC Navigation Canal suffers least from this handicap. The distance between Durgapur and Calcutta through Eastern Railway Main Line is 98 miles while it is 114 miles by road and only 120 miles by DVC Navigation Canal. This will have a great influence in reducing the cost of transport. After ascertaining all the necessary details the probable freight charges are likely to be appreciably lower than those charged by the railway and substantially below the road freight.

In outlining some of the problems in the introduction of navigation, primary mention may be made of the lack of a suitable boating organisation. While inland water transport is gradually losing ground in this part of the country, the DVC canal will provide a new scope for business if the cargo is assured. Among the different commodities again, coal constitutes the bulk, which in turn gives rise to the problem of transporting it from the coalfields to the canal head. It is hoped that the multifarious moves taken by the D. V. Corporation towards this end will meet with success in the near future and the Navigation Canal, on its completion will prove its usefulness before long.

CONSTRUCTIONS ÉLECTRIQUES
SCHNEIDER
LE MATERIEL ELECTRIQUE SW PARIS FRANCE
LICENCE
WESTINGHOUSE

POWER TRANSFORMERS for
ANDHRA GRID



TADEPALLI SUBSTATION: *Two 7,500 KVA 132/66-33kV core type power transformers with off-load tap switch on HT and ratio switch on LT*

Heavy Electrical Plant for • Hydro and Thermal Power Stations and Substations

Electric Traction •

Heavy Industrial Motors •

Telecommunication Euqipment for • 25,000 Volts 50 Cycles

Ignitrons •

Silicon Rectifiers •

LE MATÉRIEL ÉLECTRIQUE S-W
(SCHNEIDER-WESTINGHOUSE)
Paris, France

Exclusive Distributors

BLUE STAR

BLUE STAR ENGINEERING CO. (Bombay) PRIVATE LTD.
Kasturi Buildings, Jamshedji Tata Road, Bombay 1
Also at CALCUTTA · DELHI · MADRAS

PSBS-23/59

Barber-Greene

Finishers

FOR HIGHEST QUALITY BITUMINOUS PAVING

The B-G Finisher spreads, compacts and levels automatically. It automatically adjusts to irregularities in sub-grade . . . measures the correct amount of material . . . produces a durable surface that remains stable under traffic.

PRODUCES SUPERIOR SURFACES at speeds up to 64 feet per minute.

PAVES VARIABLE WIDTHS. Regular 10′ mat can be reduced to 8′ or expanded to 14′.

USES EVERY TYPE MIX—hot or cold from clay stabilized gravel to sheet asphalt.

SAVES MAN POWER & TRUCK TIME.

see your

Barber-Greene BG

distributor

"Ask Jacks about it"

William Jacks & Co. Ltd.

(Incorporated in England. Liability of Members Limited)

CALCUTTA BOMBAY MADRAS

Sole Agents for

Barber-Greene Overseas, Inc., Aurora, Illinois, U.S.A.

Barber-Greene Olding & Co. Ltd., Hatfield, Herts, England.

---

when others can't tackle the job

BEDFORD

will!

Lowest priced in its class ★ 19500 G.V.W.

Wherever tough transport jobs are being done, you'll most often find Bedfords doing them. That's because long experience in the transport business has convinced operators all over the world that Bedfords stand up well when hauling maximum payloads under all road and operating conditions.

Easy and attractive hire purchase terms offered by Hindustan Motors Corporation Ltd. Contact your dealers for particulars.

BEDFORD

A Product of General Motors
World's largest automobile manufacturers

Diesel or Petrol

HINDUSTAN MOTORS LTD., CALCUTTA

Dealers at :

Agra; Ambala Cantt; Ajmer; Ahmedabad; Ahmednagar; Allahabad; Baroda; Bangalore; Bhopal; Berhampur; Bombay; Bareilly; Calcutta; Cuttack; Coimbatore; Dehra Dun; Drug; Dumka; Dibrugarh; Dhanbad; Gauhati; Imphal; Indore; Jaipur; Jabalpur; Jodhpur; Jalgaon; Jorhat; Jamshedpur; Jullundur City; Jammu; Kanpur; Kolhapur; Lucknow; Muzaffarpur; Madras; Madurai; Mangalore; Meerut; Nagpur; New Delhi; Nepal; Patna; Poona; Pondicherry; Rajkot; Ranchi; Sambalpur; Shillong; Secunderabad; Silchar; Srinagar; Satna; Tatanagar; Tezpur; Tanjore; Trivandrum; Varanasi Cantt; Vijayawada; Vizianagram City.

From a River of Sorrow to a River of Hope

M. K. GHOSH,
Superintending Engineer, D.V.C. Panchet.

IN India, the rivers are our richest treasure. Every year, millions of acre ft. of water run down into the seas from the numerous rivers in our country. In the ancient days, human habitations grew up on the banks and basins of the rivers. The mighty rivers like the Ganges, Jamuna and Indus formed the very stage on which the Indian civilisation danced with mirth and prosperity for many centuries. The water resources of the rivers remained the main life-line of all the activities of the people for a long time.

Most of the Indian rivers take their birth in the hilly regions of the land and flow down into the seas. During the rainy season, the rivers rise in spate. causing havoc and destructions in the regions through which they flow. While a section of the land derives benefit from the flood, the larger areas in the country, specially those in the lower valleys, suffer from inundation causing enormous loss of life and property and untold miseries to all the inhabitants of the localities.

In the olden days, rivulets and streams were made to serve the cause of mankind by diverting their water for irrigation and drinking purposes. But the big rivers remained all along untamed and people used to be the helpless spectators of vagaries, devastation and destructions they caused.

With the advancement of science, it has now become possible to control and tame even some of the furious rivers of the country. Many such rivers in the South have already been tamed and turned into rivers of profit. In the north, where the rivers are bigger, measures are being taken for taming them and utilising their resources for the benefit of the mankind.

D.V.C.

The Damodar Valley Development Scheme is one such measures for the control of the river Damodar and its tributaries. The need for the control of the river Damodar, commonly known as 'River of Sorrow', was felt in the year 1943 when it had caused a catastrophic damage to the entire lower valley by heavy floods. Mr. W. A. Voorduin, TVA Engineer was brought to India to prepare a comprehensive master plan for the development of Damodar basin. He advised Government of India to make the scheme a multipurpose one and on his recommendation, the DVC was set up for the all-round development of the Valley. The complete scheme envisaged construction of Dams, supply of irrigation, industrial and drinking water, soil conservation, power generation and navigation. Accordingly, work started on all fronts as far as practicable, almost simultaneously.

THE DAMS

Four mighty Dams—at Tilaiya, Konar, Maithon and Panchet tower high today above the river beds that wind through the region. Hydro-electric Stations at Tilaiya, Maithon and Panchet dams together with the Thermal Power Station at Bokaro send power humming along the net work of 1,012 miles of Transmission lines. The water discharged from the dams is diverted into the fine net work of canals through a gigantic Barrange at Durgapur which forms the heart of the lower valley's irrigation system and supplies water to 1550 miles of irrigation and navigation canals. The principal irrigation-cum-navigation canal provides 85 miles navigational waterway joining Durgapur—the Ruhr of India with Calcutta.

The 19 crore Dam at Panchet Hill across the main Damodar is the biggest of all the dams so far built by DVC. It is a composite dam of earth and concrete and is about 22,155 ft. or about 4½ miles long.

About 140 major types of earth moving equipment and machinery were engaged in the formation of the earth dam and the concrete dam, besides several minor types of equipment and other plant. The total value of the equipment both major and minor and the concreting plant works out roughly to 2 crores 20 lakhs. The value of the spares consumed is roughly 1 crore 10 lakhs.

The capital out-lay on account of machines is appreciably less as Panchet, being the last of the project for execution, had to accept used and old machines from other projects at their written down value. It has to be always borne in mind that the last project of an unified development scheme is the "Catch all" for all headaches in having to utilise old and partially used equipment and materials. An enormous quantity of spares has to be procured and kept stock-piled so as to assure a trouble free and efficient operation. The stock-piling is also essential owing to procurement difficulties and import restrictions. There are instances when spares indented for having arrived long after the need for them ceased to exist, with the inevitable result that they have to remain unused to be disposed of eventually at a later date. Again, non-availability of particular items of spares at the right moment caused immobility to the machines resulting

in delay in the execution of works with consequent postponement of target dates and increase in cost.

The heavy stock-piling that we are compelled to do by force of circumstances leaves us at the end of the work with a large stock of unconsumed spares. This is unavoidable. A careful study of the similar dam construction projects in India by mechanised equipment, like Hirakud, Bhakra, etc., will undoubtedly reveal the same state of affairs.

The most interesting piece of the mechanised unit is the concreting plant wherein the entire operation starting from crushing of boulders into aggregates to final placement of concrete in position is fully mechanised. Another interesting equipment engaged in the constructional work is the Euclid loader used for excavation of earth required for embankment. It is able to cut and load simultaneously 12 cu. yds. of earth on to a dumper within 40 seconds.

The old and used earthmoving equipment were practically in the last stage of their life. Still, taking into consideration the available actual working hours during the working seasons from 1955-1958, it was noticed that the efficiency of the earthmoving equipment was not altogether unsatisfactory. It was on an average of 44% in the case of excavating units and 33% for hauling units. For tractors, dozers, graders and other equipment, it was between 20 to 30%. The average hourly production of the Euclid loader works out to 409 cu. yds. and for a 2½ cyds. shovel, it was 119 cu. yds.

BENEFITS

Panchet dam, as it stands today, serves the flood control objective of the Damodar river, supply water for irrigation and adds 40,000 kW of peaking power. The works have already begun to yield perceptible results which can be summarised as follows:

(1) With the completion of Maithon and Panchet dams, flood protection upto a maximum of 6,50,000 cusecs has been assured.

(2) The four reservoirs, already completed, are able to supply water for the khariff irrigation to one million acres of land in the fertile delta area around Burdwan. In fact, in 1958, five lakhs acres of land received the irrigation water for cultivation yielding bumper crcops.

(3) The incidence of malaria around Burdwan has been partially controlled.

(4) The main canal, 85 miles long, is now ready to provide facilities for inland navigation from Calcutta upto Durgapur pond.

(5) All the sand brought down by the Damodar and Barakar rivers is completely trapped in the Panchet and Maithon reservoirs, thus saving the river channel in the lower valley from further deterioration.

(6) Considerable quantity of sand will be stored in these reservoirs which can be used in the nearby coal mines for stowing purposes.

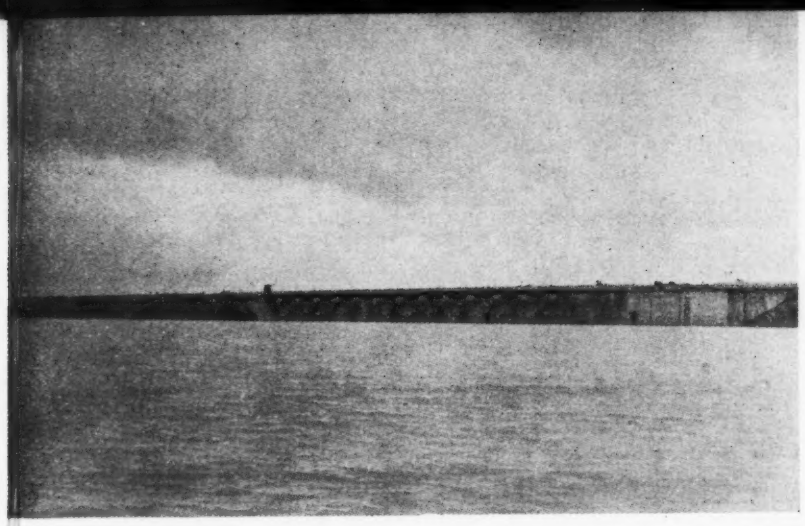
(7) The water stored in the reservoirs is used for generating the valuable peaking power. The Maithon and Panchet Hill hydel stations together can meet 100 mW of peaking power and supply some 250 million kWh annually.

(8) Water released from the Dams is now being used for cooling purpose at Bokaro and will be so used at Chandrapura and Durgapur when the thermal power stations at these places go into operation. The water can also be used by many industries at Bermo, Sindri, Dishergarh, Kulti, Burnpur, Raniganj and Durgapur. It can also afford opportunities for providing improved water supply installations to Jharia Water Board, Chandrapura, Asansol, Durgapur and other industrial township.

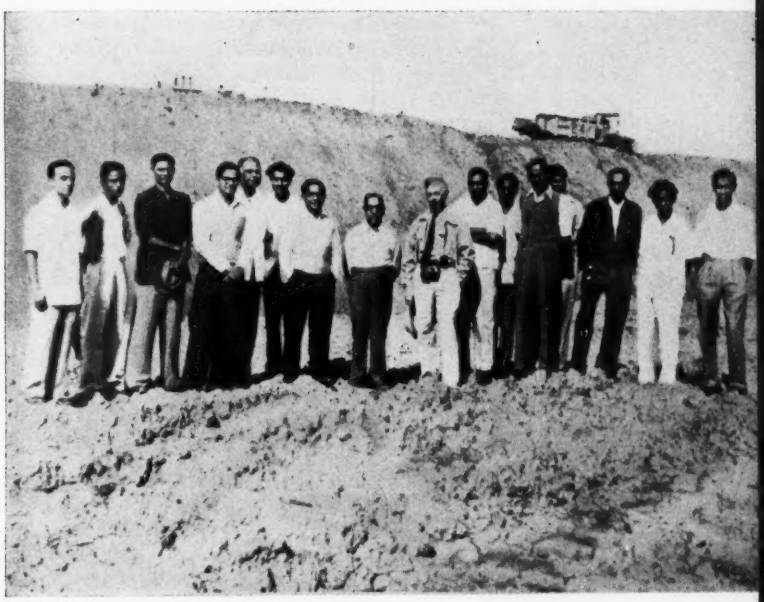
AGENCY OF CONSTRUCTION

It has so far been the practice in our country to entrust the construction works to contractors—mainly on the ground that it is difficult to deal with the labour departmentally. A considerable sum of money is given away as profits to contractors which can be better utilised on the welfare of labour. With better living conditions, amenities and recreation facilities, more work can be got out of the workers. It is gratifying to note that in many industrial undertakings, the State is assuming direct control by eliminating the private enterprise. On the same analogy, it is hoped that the State will begin to favour the execution of major constructional undertakings by eliminating the middle men and establishing direct relationship between the employers and the employees. In DVC, at Panchet, Maithon and Tilaiya, all principal works of construction have been done departmentally and without the agency of any contracting firms and it can be confidently said that "quality" works have been done within the cost and the time schedule. With the experience gained, works of greater magnitude can be executed departmentally both economically and expeditiously.

All of us have heard of the package deals which have been entered into with the foreign contracting firms in the execution of a good many number of Heavy industries projects in the first and second Five Year Plans. While at the initial stages of development, the need for such deals can be favoured and justified, it is hoped that beginning with the next Five Year Plan, it will not be considered necessary to enter into such deals with any foreign firms. This type of deals afford no scope to Indian engineers and other technical personnel to gain first hand experience of the works. The foreign contracting firms securing the deals bring most of the key personnel from their own lands and whatever Indian engineers and technical personnel are there on their roll by virtue of the terms and conditions of agreements, they remain on the jobs merely as onlookers. Nothing can be more harmful and suicidal to the nation than these package deals which deny scopes to the country's own engineers and other talents and make the nation continually dependent on foreign engineers and tech-



Panchet Dam (Upstream View)



Chief Engineer Komora with his team of Constructors at Panchet.

Panchet Dam (Downstream View)

nicians. In lieu of the package deals, the departmental execution of works is advocated as this will afford sufficient opportunities to the sons of the soil to acquaint themselves with all the technicalities associated with the works and the country can thereby become self-sufficient in engineers and other technical personnel very rapidly and need not look for aid from foreign countries in its future developments and nation building schemes. All around us, we find today plenty of foreign technicians who have been engaged on payment of large sums of money and valuable foreign exchange which are essentially required for the development of our land. The foreigners are there even for ordinary jobs of carpenters, fitters, welders, riggers, etc. At Panchet, Maithon and Tilaiya, our own men have done the erection jobs. Our men have assembled and repaired the most modern heavy machineries and equipment. The hydro-electric turbines and generators obtained from abroad have been wholly assembled and erected by our own engineers and technicians, the foreign supervisors from the supplying firms standing by as advisers. I cite the above instances just to stress that given a chance, the Indian engineers and technicians are capable of doing things admirably well. In fact, one of the top construction men of America, who visited Panchet Project sometime back, remarked "I wish, I have these men in my country on my jobs". "Indian engineers are second to none", observed Mr. Komora, the late Chief Engineer, DVC, on his relinquishing the charge of office in the DVC. There can be no better testimony to our ability than these kind observations of eminent foreign engineers.

PANCHET CONSTRUCTION ORGANISATION

From Tilaiya through Maithon to Panchet was a long way and the momentum of construction speed gained from project to project had been really admirable. At Panchet, the construction organisation had developed into so well knit a unit that one could see everything to move with clocklike regularity. In a press interview, commenting on the Panchet team, Mr. Komora remarked "As of today, the construction organisation at Panchet is equal to that of any in the world". He added "It would be wise for the Government to transfer this group, in tact in so far as possible, on to a new project. A certain price has been paid for training the men to do their various jobs. This training would pay dividends on another similar project."

There existed a most cordial relationship between the officers and workers throughout all the stages of the work. They understood each other perfectly well. While the officers treated their men with kindness and affection the workers on their part moved about with a high sense of devotion and loyalty in them. Discipline in the sphere of work and even outside was strictly maintained by both officers and men. They worked in perfect harmony each shouldering and discharging his own responsibilities. Even the spectre of the impending retrenchment stalking before them could not unnerve or deter them. They did their job till completion unflinchingly and according to the schedule.

Men uprooted from the submergence areas having lost their hearth and homes and means of livelihood were treated with special care. As far as possible, preference was given to them in employment. Practically all the unskilled labours and kamins hailed from the neighbouring localities. Some of these men have now emerged out as good artisans and skilled workmen. They can earn their livelihood elsewhere, if they so choose, with the knowledge and experience they have gained with us. Petty contracts were also given to the local men for earth works, felling and removal of the trees and roots from the submergence areas.

Under the blaze of the summer sun and driving rain, hundreds of thousands of men hewed and blasted and hauled with their teams and tractors. They pitched in, realising that the work was for their own ultimate benefits.

Today, when the work is over, the goal has been achieved and the thunderous roars of the monster machines are just a fleeting memory, our thoughts run in remembrance of our beloved brethren who dedicated their lives while in harness, serving the cause of their motherland, the humanity and the nation. They have attained martyrdom; but their spirits will be there with us to share our jubilations and the fruits of our hard and rigorous toil.

INSPECTION AND QUALITY CONTROL IN PANCHET DAM CONSTRUCTION

(Continued from page 28)

CONCLUSION

The Panchet Dam and Power House have been completed and it has been declared that a quality job has been done.

The significance of the role of Inspection and quality control in securing good quality in the construction of big projects like that of Panchet dam, is thus apparent. It will not be out of place to mention here that Inspection Wing at Panchet, though working at times with inadequate staff, did really a commendable job. It is a pity that Inspection has not always been properly understood in the true spirit of it even by our eminent engineers, not to speak of laymen. It is, however, heartening to find Inspection gaining field and coming more and more to the limelight than in the past. It is, therefore, fervently hoped that Inspection with its proper personnel and better equipments will get its due place in big projects coming up in the near future.

no hit or miss here !

There is no 'hit or miss' policy in the supply of Dunlop conveyor belts for your installation. Dunlop's world-wide experience and research are applied to the specific problems of Indian climate and conditions in the manufacture of conveyor belts at Sahaganj.

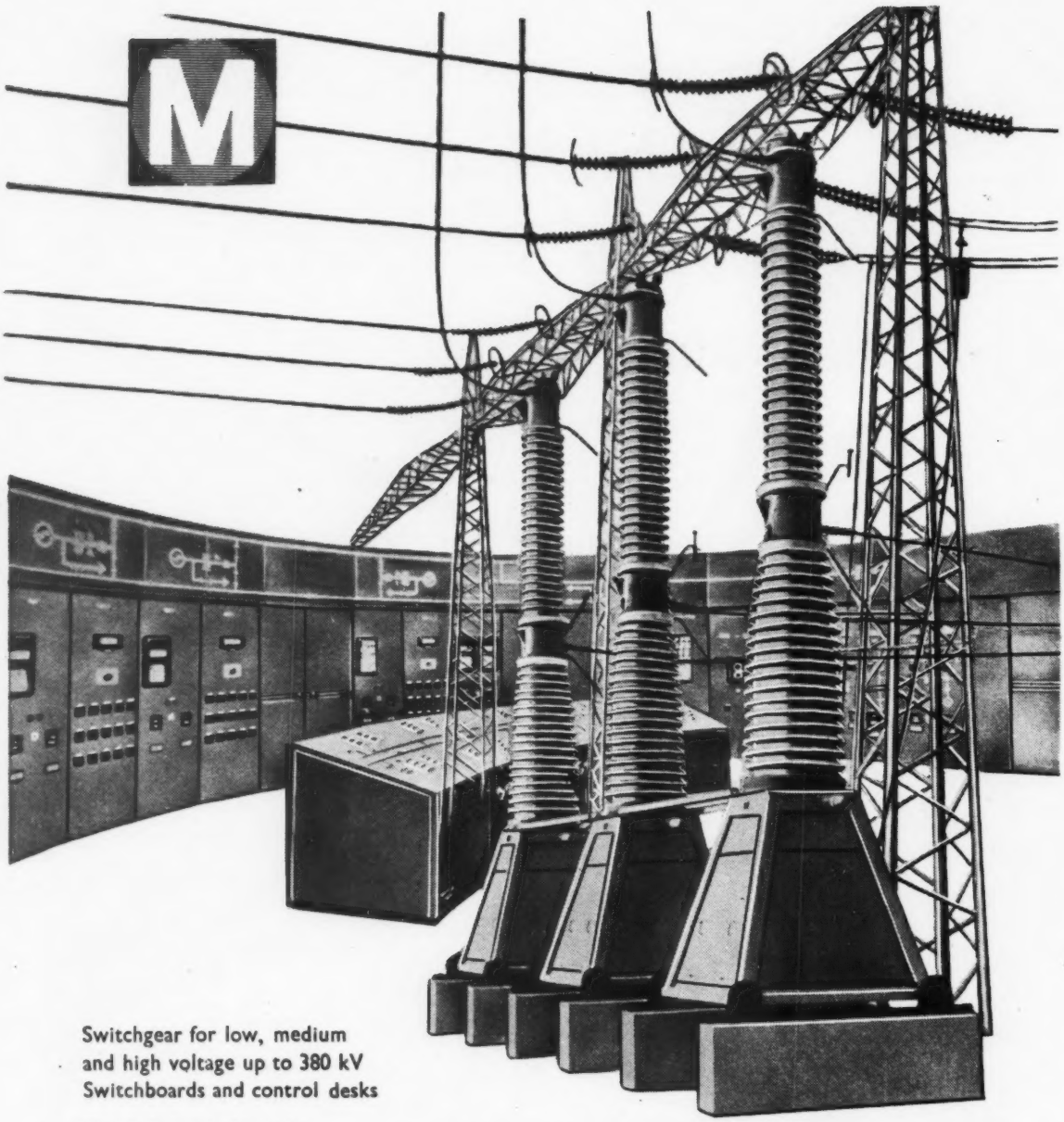
Dunlop Conveyor belts at the D. V. C. Project. (Photograph by courtesy of Eastern Equipment & Sales Ltd.)

Each belt is tailor-made to give you the optimum balance between various constructional features as best suited to your installation. Rigorous factory tests ensure top quality in supplies to the customer. Splicing at site is carried out by a Mobile Splicing team, an aspect of a thorough after-sales service in the field.

DUNLOP

conveyor belts

DRAC-31



Switchgear for low, medium
and high voltage up to 380 kV
Switchboards and control desks

Metal clad switchboards
for indoor and outdoor
installation lighting arresters

MAGRINI

S. p. A.

Head Office. factory and export section - Bergamo

Agents:

EASUN ENGINEERING CO. LTD.,

5/7 Second Line Beach. Madras - 1 Phone: 31221 (4 lines) Cables :"EASUN", Madras
Suite D. 4. Bharat Bhawan, No. 3, Chittaranjan Avenue, Calcutta - 13
Gobind Mansion 'H' Block, Connaught Circus, New Delhi
Also at London, Bombay, Bangalore, Madurai

Design of Panchet Hill Dam & Powerhouse

By N. M. CHAKRAVARTY,
Superintending Engineer (Design),
DVC, Maithon

FLOOD control by means of reservoirs had been under discussion since the middle of the last century and several reports were prepared recommending certain sites for construction of dams in the Damodar catchment.

As a result of 1943 flood, a concrete step was taken in this direction and the Central Technical Power Board was set up by Government of India in 1944 with Mr. W. L. Voorduin, an American expert, as the Hydro-Electric Member.

Mr. Voorduin, in his Preliminary Memorandum envisaged a multipurpose scheme for the development of the Damodar Valley, the primary consideration for which was the control of floods. In his report he recommended the construction of eight storage dams capable of controlling floods with a peak flow of one million cusecs and a hydro-electric station at each of these reservoirs with a total generating capacity of 200,000 kW.

In the year 1948, Damodar Valley Corporation was formed to take up the detailed design and construction of the above projects. The Corporation decided to implement the scheme in two phases with slight modifications to the original scheme.

The first phase consisted of four storage dams at Tilaiya, Konar, Maithon and Panchet Hill with the connected hydro-electric stations, the Bokaro Thermal Station with the power transmission grid and the irrigation barrage and canal networks. Konar hydro power station, however, was not constructed during the 1st phase. The design of flood protection was also reduced in the first phase from one million cusecs to 650,000 cusecs, as a measure of economy. The flood cushion provided in the four dams proposed in the first phase is capable of controlling floods of this magnitude and also covers all floods recorded in the last 100 years.

This has been effectively demonstrated during the flood that occured during September 1958, caused by a heavy rainfall over a period of three days.

At Panchet the maximum observed peak inflow was 430,000 cusecs and that recorded at Maithon was of the order of 170,000 cusecs. The downstream river channel capacity of 200,000 cusecs was not exceeded by allowing a controlled outflow of 180,000 cusecs through Panchet dam and an outflow of 5,000 cusecs through Maithon dam. Similarly, Konar and Tilaiya dams also contributed their share of flood control by absorbing a total inflow of about 50,000 cusecs and thereby restricting the total flood volume at Maithon and Panchet dams.

If no dams had been built the maximum peak flow at Durgapur Barrage would have recorded about 665,000 cusecs.

It may be noted that the 1943 flood which caused such havoc during the war years was less than half the magnitude of this flood.

GEOLOGY

The geology of the region mainly consists of two principal groups—the Archaeans and the Gondwanas and the junction of the two formations cross the river obliquely. The Archaean-Gondwana boundry has been affected by a number of cross faults of a later age. These cross faults have a general NW-SE trend.

Garnetiferous and Micaceous Augean-Gneisses are generally exposed on the left bank and the soil cover in this region is thin and local. A natural depression occurs on the left bank and to the north of the depression, the country is entirely soil covered but sub-surface exploration indicated that underlying rocks are mostly granulites with subordinate horn-blende-gneisses, biotite-gniesses, schists etc. Thus the depression, which was also covered with soil, had actually occurred at the junction of garnetiferous and non-garnetiferous rocks. Garnetiferous and Micaceous Augean-Gniesses also underline the sand and gravels along the entire river bed. On the right bank, Garnetiferous and Micaceous Augean-Gniesses occupy only a small area near the bank of the Utlan Nullah.

PURPOSE

The topography of the Damodar region makes it impossible to locate any dam which would provide substantial storage capacity below the confluence of the Barakar with Damodar river.

Panchet Hill dam, along with Maithon dam on Barakar river will be primarily operated for flood control. It has been observed that all storms in the Valley are local and the flood storage capacity in the upper dams will not be of much help if a severe storm occurs in the lower region.

To overcome this danger, Maithon and Panchet

Hill dams, which are both ideally located in the lower reaches of the Valley have been designed to catch all floods originating in the basin. The upper portion of Maithon and Panchet reservoirs will be used as retarding basins.

Another advantage of this scheme is that all lands in the basin above the pre-flood level will be rarely submerged, and the land above will not be acquired and can be utilised for growing rice.

The loss of power and irrigation storage at these two dams is compensated by the maximum power and irrigation storage available at the beginning of the dry season from other dams in the higher reaches.

LAYOUT

Panchet Hill dam is located on the Damodar river in the district of Dhanbad, Bihar, and about three miles above its confluence with the Barakar river. Its drainage area is 4,234 sq. miles.

Panchet Hill dam is made up of a composite structure of concrete dam with contiguous earth embankments on the left and right side of the concrete structures. Two saddle dikes, one at each extreme end of the earth embankments, are also included in the overall layout (Ref. General Plan). The river bed has an alluvial deposit of sand with a maximum depth of 50 ft above bed rock. This was one of the main reasons for locating the main earth dam on the river bed. Before finalising the present alignment, more than a dozen different alignments were examined and abandoned because of faults revealed in these alignments during preliminary geological investigations.

The layout (Ref. Concrete Dam—Plan & Elevation) includes a concrete gravity type spillway 765 ft long flanked by non-overflow sections of 322.5 ft to the right, including the two intake blocks of 72 ft each, for the powerhouse. To the left, the spillway is flanked by concrete non-overflow sections of 127.5 ft. The spillway blocks, 15 in number and each 51 ft long are located in the diversion channel, excavated for passing the flow during the construction stage.

The maximum height of main earthdam is about 140 ft and that of concrete dam about 150 ft above foundation level. The maximum height of concrete dam, above deepest foundation level is 167 ft.

The end blocks of the abutment sections are each embedded for a length of 40 ft into the adjacent embankment fills to provide adequate seepage control. Retaining walls upstream and downstream, on either side of the concrete dam are provided to retain the embankment fill abutting against the concrete dam at each end and also to guide the flow through the spillway and intake blocks.

DESIGN

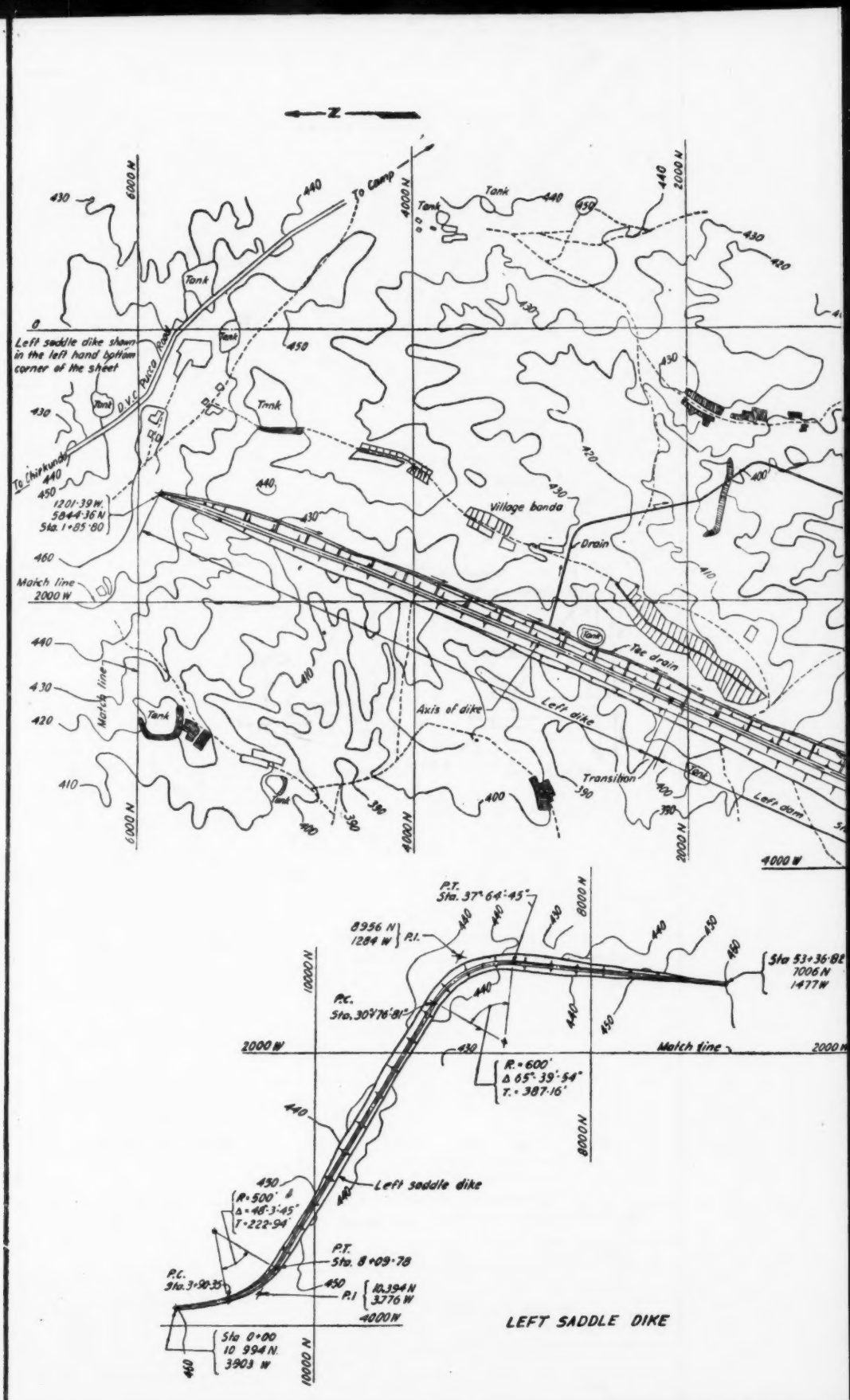
Main Earth Dam

The main earth dam (Ref. Main Earth Dam—Typical sections and Plan—Main Earth Dam & Right Dam) on the river bed has been designed as a zoned fill embankment with an inverted 'T' shaped impervious central core having adjacent shoulder fills on either side. The shoulder fill materials are composed of impervious, semi-pervious and pervious graded materials, placed in layers with finer rollable materials near the core and coarser materials towards the outer ends. The coarser materials were compacted with tractor passes. The impervious material of the core was compacted by sheep-foot roller passes.

The vertical arm of the central core is 30 ft wide on top and 100 ft at bottom. The base of the core extends as an impervious blanket 600 ft upstream from the axis of dam, and the downstream arm of the base has a length of about 218 ft from the axis. The impervious blanket at the upstream toe has been provided to minimise seepage losses. In addition to the impervious blanket, a single row of steel sheet piles has been driven through the sand bed into the bedrock below. The sheet piles are located 20 ft upstream from the axis of the dam and project 20 ft into the impervious core above the river bed.

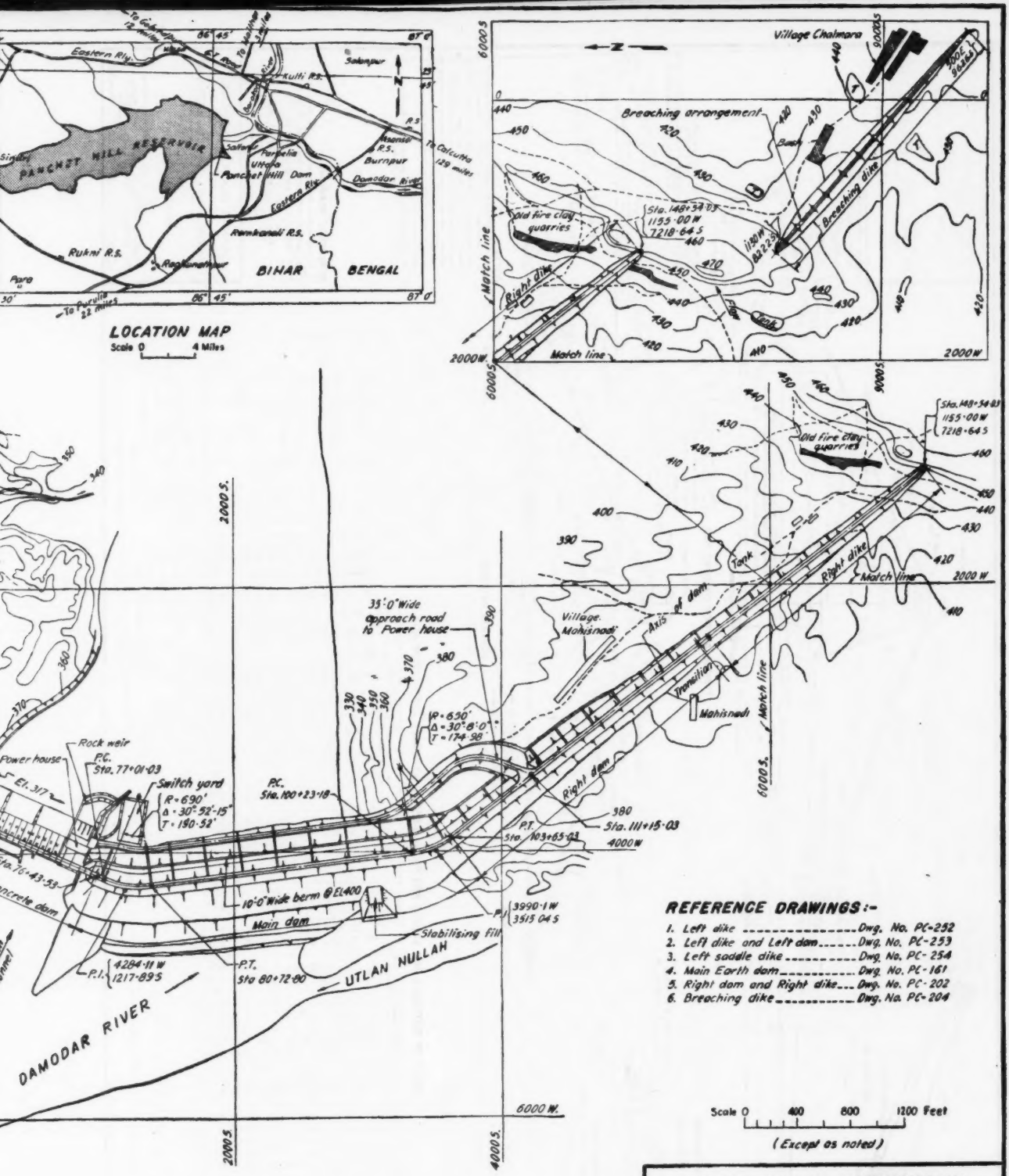
This main dam extends some distance beyond the river channel, to the right as zonal fill but without having sheet piles and impervious blanket at the base. The right embankment on the bank, above ground elevation 400, has been continued upto the end as a homogeneous fill. A transition section 100 ft long has been provided between the zonal fill and homogeneous fill structures. The total length of right embankment is about 7,210 ft. The left embankment, with a total length of about 6,240 ft also starts as a zonal fill from the left end of the concrete dam and continues as a homogeneous fill over high ground further beyond. Beyond the left embankment, at the extreme end, a low saddle dike about 5,340 ft long is located. A breaching dike, about 2,150 ft long, has been provided at the further end on the right bank, to act as a fuse plug when the maximum pool level rises above E1.449 during an extraordinary flood. The top elevation of the breaching dike, in the centre, has been kept lower than the general top elevation of the dam, by eight feet, so as to facilitate the breaching action of the safety plug in case the reservoir level starts rising above the top of the spillway crest gates.

The upstream side of the earth embankment is protected by means of rock rip-rap of varying thickness with a horizontal to vertical slope of 3:1 for the most part. (Ref. Typical sections—Main Earth dam). The riprap is placed over a 10″ thick layer of graded crushed rock which extends 15 ft below the minimum pool level and is provided to act as a reverse filter preventing carrying away of fine materials by wave action or during draw-down. The downstream side has a horizontal to vertical slope of 2.25:1, interspersed with 3 berms 10 ft to 35 ft wide at three different elevations. The downstream toe is



LEFT SADDLE DIKE

LEFT SADDLE DIKE



REFERENCE DRAWINGS:-

1. Left dike ..... Dwg. No. PC-252
2. Left dike and Left dam ..... Dwg. No. PC-253
3. Left saddle dike ..... Dwg. No. PC-254
4. Main Earth dam ..... Dwg. No. PC-161
5. Right dam and Right dike ... Dwg. No. PC-202
6. Breaching dike ..... Dwg. No. PC-204

Scale 0 400 800 1200 Feet

(Except as noted)

DAMODAR VALLEY CORPORATION	
PANCHET HILL	PROJECT
GENERAL PLAN	
	DWG.NO. PC-40

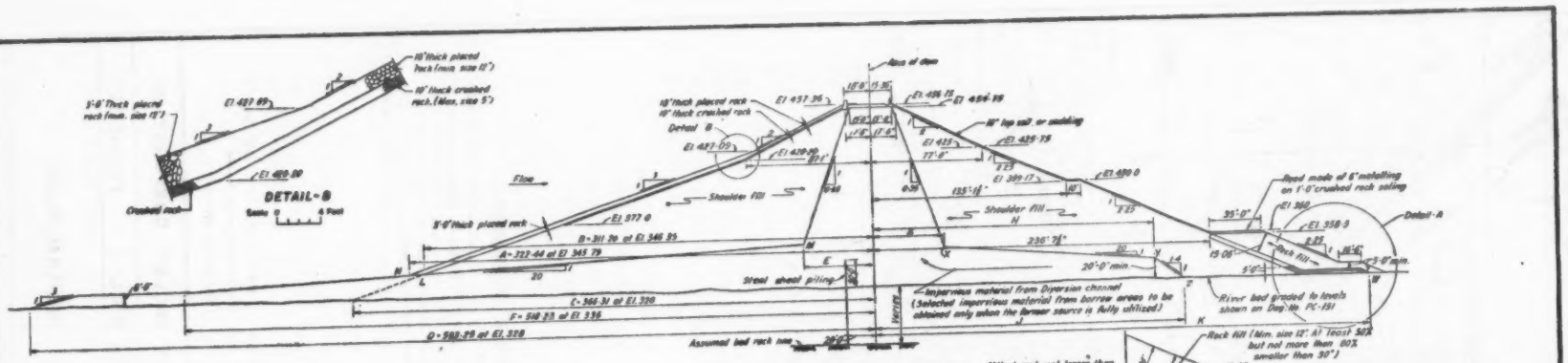

DETAIL-B
TYPICAL SECTION ON RIVER BED
DETAIL-A
DOWNSTREAM TOE
(Stripped ground between El 360 to El 355)
SECTION ON BANK
Axis of dam
Flow
Shoulder fill
Steel sheet piling
Impervious material from Diversion channel
(Selected impervious material from borrow areas to be obtained only when the former source is fully utilized)
Assumed bed rock line
Rock fill
Road made of 6" metalling on 1'-0" crushed rock soling
River bed graded to levels shown on Dwg No PC-191
Rock fill (Min. size 12" A) Least 50% but not more than 60% smaller than 30")
18" thick crushed stone 1"to 8" size can be layered such as - 1"to 3", 4" thick 3"to 6", 6" thick 6"to 8", 8" thick
With coarser layers towards rock fill
River bed sand
18" thick crushed stone well graded from ¾" to 1"
Rolled fill
Stripped for firm base
Prepared foundation line
Stripping
Road made of 6" metalling on 1'-0" crushed rock soling
3'-0" thick graded rock as described in detail-B
Selected impervious material
Shoulder fill
Rock fill
Detail-A
Detail-B

TABLE OF DISTANCES AND LEVELS FOR FIXING FEET OF DIFFERENT SLOPES FROM AXIS

Prepared elevation of foundation	Upstream slope									Downstream slope							
	Distance from axis of dam in feet						Elevations			Distance from axis of dam in feet				Elevations			
	A	B	C	D	E	F	M	N	L	G	H	J	K	X	Y	Z	W
328	322·44	311·26	366·31	593·25	48·43	348·23	359·49	345·79	346·35	49·90	190·49	210·49	346·65	355·03	348	328	328
329	319·32	308·14	363·31	591·00	48·11	345·91	360·39	346·83	347·39	49·52	191·09	219·89	344·40	356·12	349	329	329
330	316·20	305·02	360·31	588·75	47·80	343·60	361·29	347·87	348·43	49·14	191·29	221·29	342·15	357·21	350	330	330
331	313·08	301·90	357·31	586·50	47·48	341·28	362·19	348·91	349·47	48·76	194·69	222·69	339·90	358·30	351	331	331
332	309·96	298·78	354·31	584·25	47·17	338·97	363·09	349·95	350·51	48·38	196·09	224·09	337·65	359·39	352	332	332
333	306·84	295·66	351·31	582·00	46·85	336·65	363·99	350·99	351·55	48·00	197·49	225·49	335·40	360·47	353	333	333
334	303·72	292·54	348·31	579·75	46·54	334·34	364·89	352·03	352·59	47·62	198·89	226·89	333·15	361·56	354	334	334
335	300·60	289·42	345·31	577·50	46·22	332·02	365·79	353·07	353·63	47·24	200·29	228·29	330·90	362·65	355	335	335
336	297·48	286·30	342·31	575·25	45·91	329·70	366·69	354·11	354·67	46·86	201·69	229·69	328·65	363·74	356	336	336
337	294·36	283·18	339·31	573·00	45·59	327·39	367·59	355·15	355·71	46·48	203·09	231·09	326·40	364·83	357	337	337
338	291·24	280·06	336·31	570·75	45·28	325·06	368·49	356·19	356·75	46·10	204·49	232·49	324·15	365·91	358	338	338
339	288·12	276·94	333·31	568·50	44·96	322·74	369·39	357·23	357·79	45·70	205·89	233·89	321·90	367·01	359	339	339

NOTES :-

1. Selected impervious material from diversion channel excavation, to be spread in 6"to 8" thick layers a rolled. Borrow to be topped after material from diversion channel is used up.
2. Shoulder fill material to consist of impervious, semipervious and pervious materials and to be spread with finer and pervious materials and to be spread with finer reliable material nearer to impervious core and coarser material towards outer ends. Coarser material may be spread in layers of 6" to 12" thick and compacted with passes of caterpillar tractor.
3. For toe details at stripped ground El 370·0 and above, ref Dwg Nos PC-252 and PC-253

REFERENCE DRAWINGS :-

1. Impervious rolled fill on river bed ..... Dwg Nos PC-152, 154 & 159
2. Main earth dam & right dam - Plan, sheet-I ..... Dwg No PC-161
3. Crest detail ..... Dwg No PK-500, 501

Scale 0 30 60 90 Feet

(Except as noted)

DATE	NO	DISTRIBUTION
PRINTS		

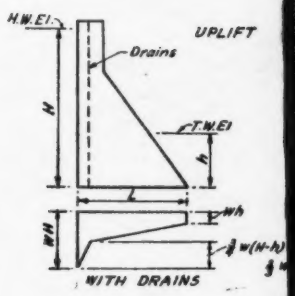
	BY	DATE	CHKD	DATE
DSGD	A.S.E. A.P.Z.		G.M.S.V.	A.R.
DWN	B.G.S.	S.S.D.	A.S.C.	M.S.N.
TYCD		M.S.N.		
RECD	A.D.O.		RECD	M.L.N. V.A.R.

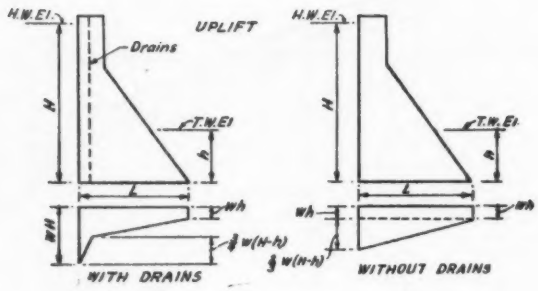
DAMODAR VALLEY CORPORATION

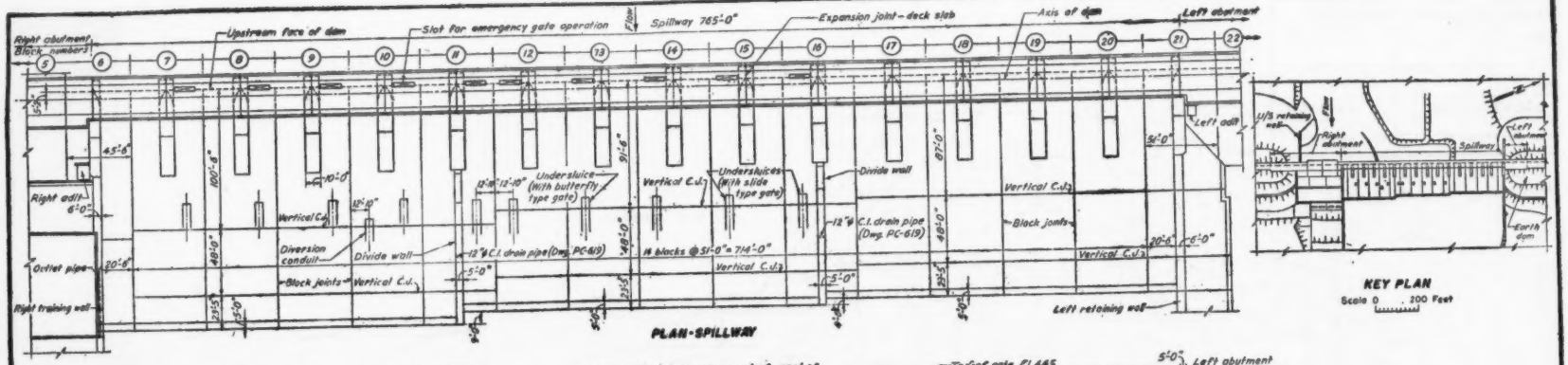
PANCHET HILL | MAIN EARTH DAM

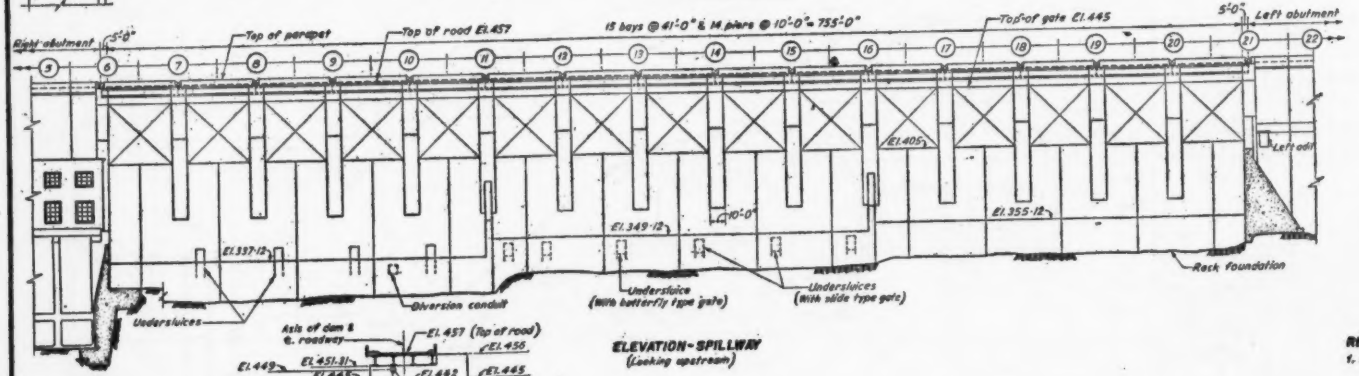
TYPICAL SECTIONS

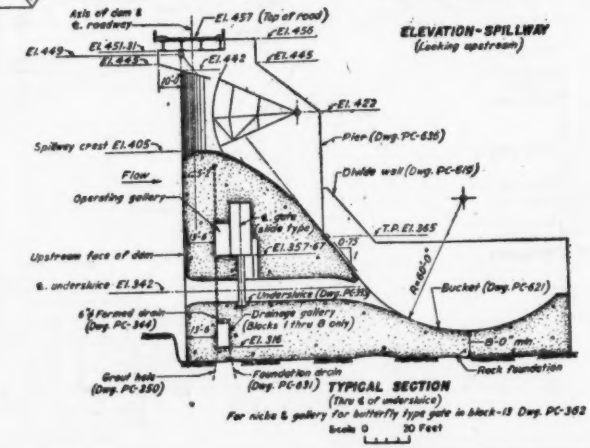
SD/- S.S. SOOREN "RESIDENT ENGINEER" KUNDA ENGINEERING COMPANY	SD/- A.N. SUNDRA "CHIEF ENGINEER, D.V.C."
SD/- B.M. CHAKRAVORTI FOR DESIGN ENGINEER D.V.C.	DATE 12.11.54 / DWG NO PC-176


H.W.El.
UPLIFT
Drains
H
T.W.El
h
L
wh
WH
WITH DRAINS


H.W.El.
UPLIFT
Drains
H
T.W.El
h
L
wh
WH
⅔ w(H-h)
WITH DRAINS
H.W.El.
H
T.W.El.
h
L
wh
wh
⅔ w(H-h)
WITHOUT DRAINS







REFERENCE DRAWINGS:-

1. Spillway excavation plan - Dwg. PC-616

Scale 0 30 60 90 Feet (Except as noted)

DATE	NO	DISTRIBUTION
		PRINTS

	BY	DATE	CHKD	DATE
DSWB				
DPWD				
TRCD				

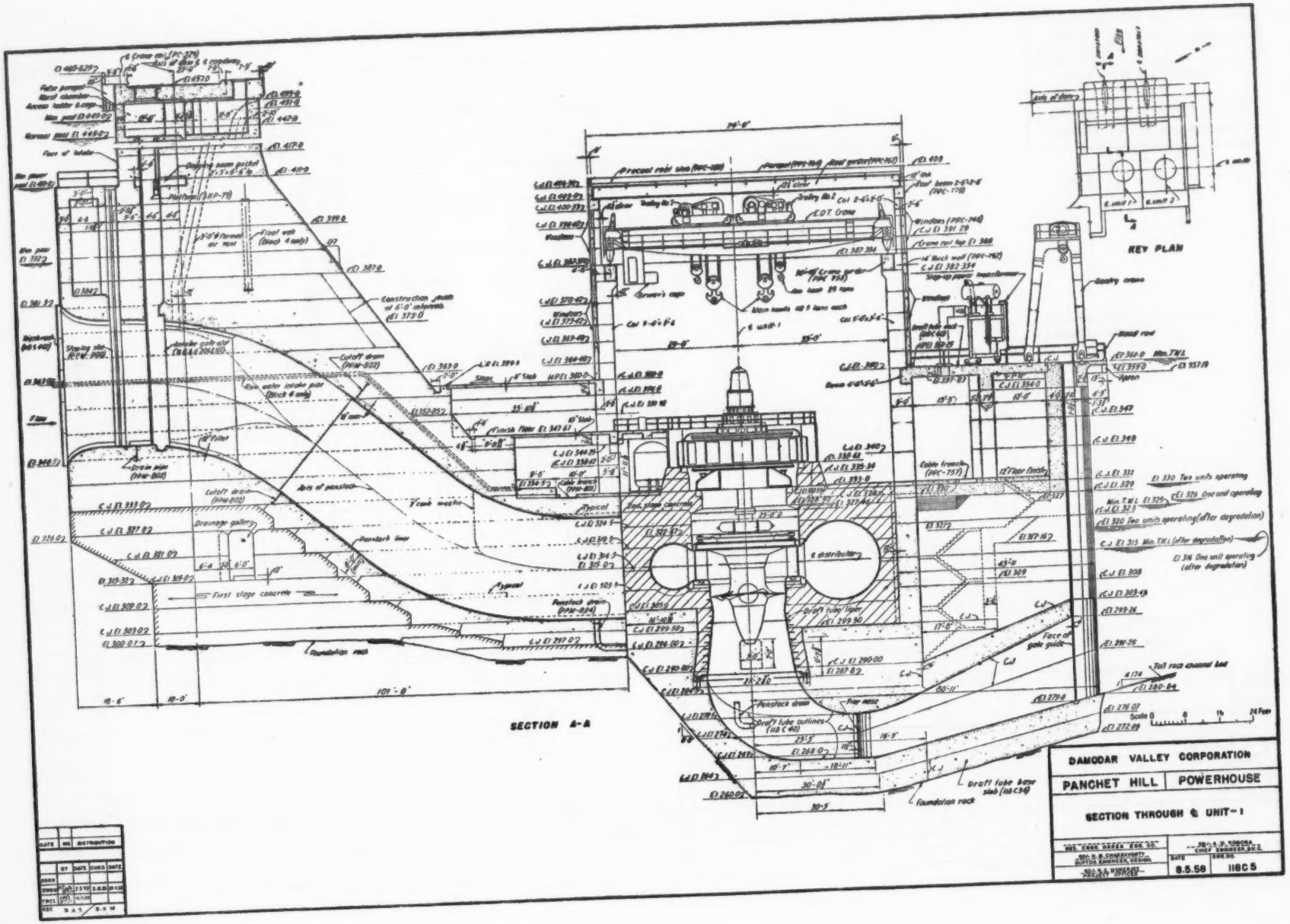
DUP. B.A.NOWAK REC. M.R.D.

DAMODAR VALLEY CORPORATION

PANCHET HILL CONCRETE DAM

SPILLWAY
PLAN ELEVATION & SECTION

SD/- WALLACE A. MILLOOD, MEE. ENGR. DIRECTOR ENG. CO.	SD/- A. M. ROMORA, CHIEF ENGINEER, D.V.C.	
SD/- N. M. CHAKRAVORTY, DESIGN ENGINEER, D.V.C.	DATE	DWG. NO.
SD/- B. C. BANERJEE, PROJECT DESIGN ENGINEER, D.V.C.	25.7.56.	PC-602


SECTION A-A
KEY PLAN
DAMODAR VALLEY CORPORATION
PANCHET HILL | POWERHOUSE
SECTION THROUGH © UNIT-1
DATE 8.5.58
DWG. NO. 11BC5

composed of dumped rock which provides the neccessary weight at the toe and also the required drainage area for seepage water. The rock toe drain rests over a 3 ft layer of filter bed consisting of graded crushed rock, varying in size from ¼″ to 8″. This filter layer, prevents the flow of fine materials from the body of the dam under hydrostatic pressure. Above the rock toe, the "Giant Star" grass seeded over 10″ in top soil covers the downstream slope and provides the necessary protection from rain-cut or scour.

Structural analysis of earth dam : The analysis of the structure was based on the intended operation of Panchet reservoir. The proposed scheme envisaged a normal pool level at El.410. During the flood season, the discharge from the reservoir is to be controlled by operating the crest gates and undersluices, so as not to exceed the capacity of the downstream river channel. The maximum reservoir level during flood stage was fixed at the top of crest gates, El.445.

Analysis of slopes after construction : The upstream and downstream slopes have been analysed for stability by the modified slip-circle method with earthquakes forces equal to 0.1 gravity applied horizontally and with construction pore-pressure acting within the impervious blanket and core. The pore pressure in fill was assumed equal to hydro-static head after draw down.

The analysis of the downstream slope under steady seepage condition, with full reservoir at El.445 and tail-water level at El.350, gives a factor of safety of 1.30.

For the upstream slope, a minimum factor of safety of 1.63 is obtained for the analysis with reservoir at El.445 under steady seepage condition.

The upstream slope when analysed for rapid draw down from reservoir elevation 445 to elevations 410 with earthquake force equal to 0.1 gravity applied horizontally gives a factor of safety of 1.37.

Borrow Materials During preliminary investigations of the site it was revealed that the overburden at the left bank was quite suitable for being used as impervious core material for earth dams. Whereas the pervious materials could be utilised for shoulder fill in earth dam and the hard rock could be used for rip-rap and rock toe or for aggregates in concrete dam. Therefore, the 600 ft wide diversion channel located on the left bank of the river and close to the main earthdam structure has proved decidedly advantageous in supplying borrow materials for earth dam and aggregates for the concrete dam. The close proximity of the earthdam to the diversion channel made it possible to utilise practically all the excavated materials from diversion channel directly in the construction of the earth dam without rehandling. Test results on the borrow materials indicated that the permeability seldom exceed 5 ft per year and that the average value was much lower. The balance of the embankment material are obtained from previously located, adjacent upstream areas.

During the stripping operations of the earthdam foundation, a clay band with extremely low shear value and composed of silty materials was exposed on the right bank of the river, running parallel to the direction of flow. The design analysis called for a stabilising fill on the upstream slope of the dam for this location. This treatment has increased the quantity of the fill materials by about 30,000 cyds.

Construction Sequence During the first construction season, the main earth dam on the river bed was only extended half the distance in the river channel. The other half of the river and a diversion channel 300 ft wide on the left bank were used to carry the river discharge during the monsoon. The section of the earthdam exposed to the flow was protected from scour by a row of steel sheet piles covered by large sized dumped rocks. This scheme has worked very successfully. During the next construction season, the diversion channel was extended to its full width of 600 ft. Three subsequent monsoon floods were also passed through this half section of the river and over the partly constructed spillway bays. During the 1958 dry season, the river was finally closed by providing a low cofferdam over the upstream blanket of the dam. The river flow was diverted through the 8.5 ft sq. diversion conduit provided in one of the spillway blocks for this purpose. During the 1958 monsoon season, the flow was passed over the low spillway blocks and through the intake blocks in the powerhouse zone.

The total quantity of fill in the embankment sections are as follows:

Earthdam	—	5,800,000 Cu. Yds (Approx).
Dikes	—	1,200,000 Cu. Yds (Approx).

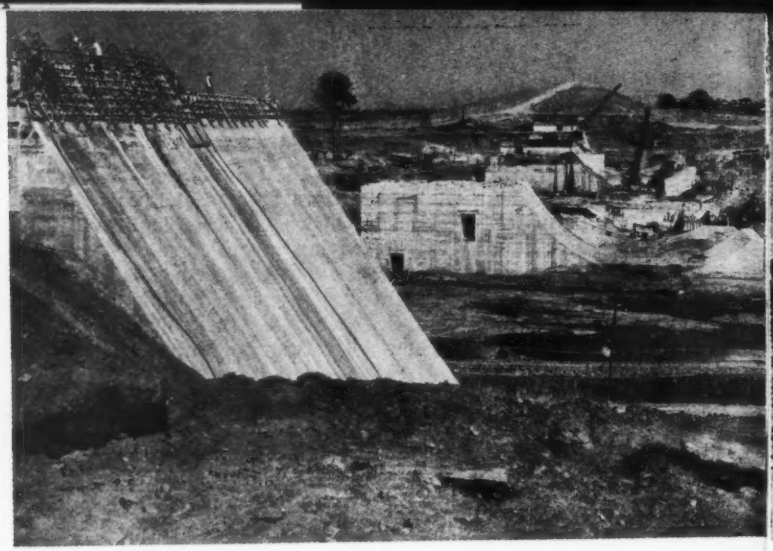
Concrete Dam

The concrete dam is situated on the left bank of the river with the spillway blocks located in the diversion channel. The entire length is divided into 23 blocks and with the exception of the two intake blocks and the two blocks adjacent to intake blocks, all the remaining blocks are of 51 ft length each.

The concrete structure is of straight gravity type vertical upstream face. The downstream face of the non-overflow sections has a horizontal to vertical slope of 7:10 and that for the spillway is 7.5:10.

Fresh rock, which is at a very high elevation at the left end of the concrete dam gradually slopes towards the right. This formation of natural foundation rock resulted in the present design of stepped spillway, to minimise cost of excavation and concreting.

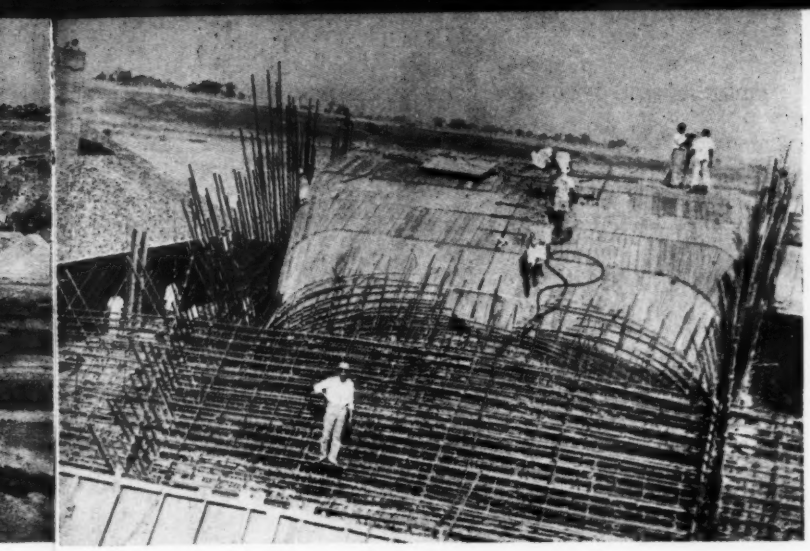
The intake and powerhouse were originally located on the left end of the concete dam because of the easy accessibility to this area from the left bank. Exploratory drilling of the rock formation indicated a natural depression at the right end of the spillway



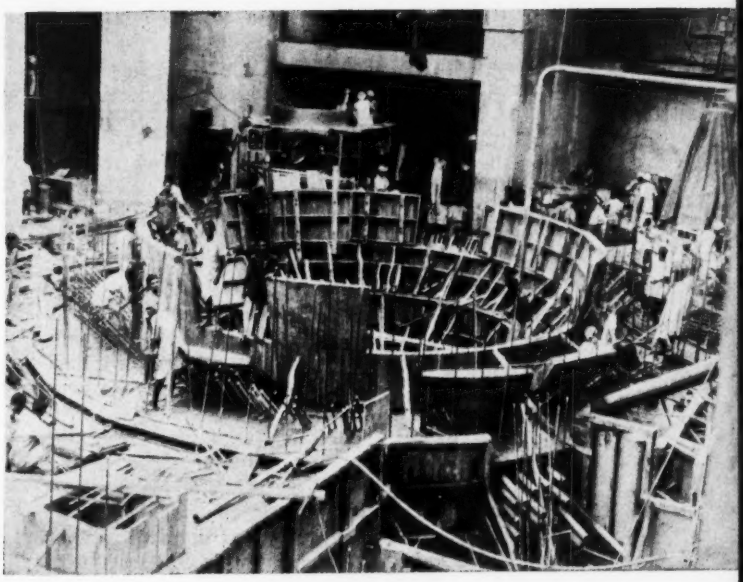
Concrete dam under construction at Panchet

Equipment at work on the Earth dam at Panchet.

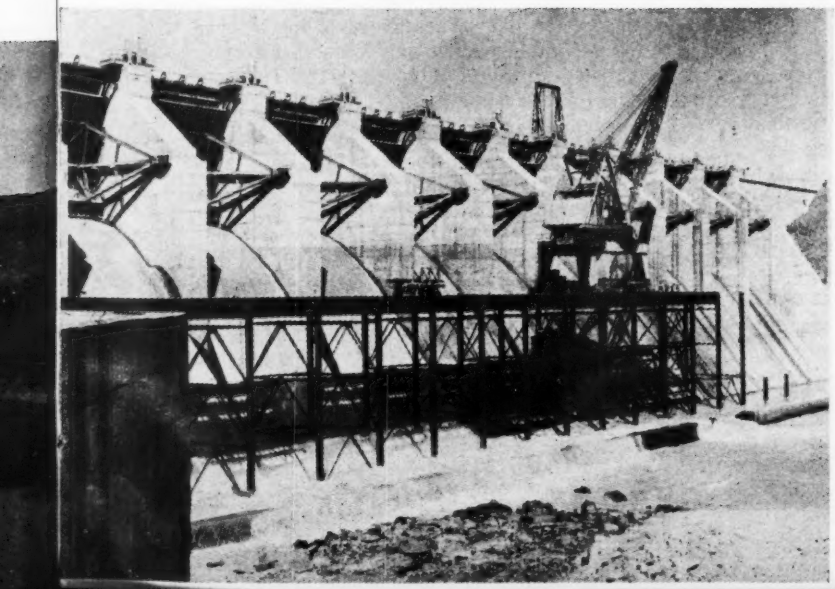
Diverting Damodar river through the concrete dam at Panchet.



Timber form work for Bell-mouth transition.



Inside the Panchet Power House



Crest gates in position at Panchet

channel which was found convenient for the final location of the powerhouse and tailrace. This resulted in substantial saving in cost of excavation and concrete backfill for the intake and powerhouse area.

The structure of the foundation rock at Panchet Hill is highly laminated and fractured. The lamination dips towards the left at an approximate slope of 45°. Existence of several faults in the rock formation was also observed after the foundation was uncovered. The general positioning of the powerhouse and the location of the tailrace channel adjacent to the spillway channel, coupled with the fact that the left bank of the spillway channel has a bend tending to deflect the flow into the tailrace channel raised a serious problem in the final selection of the type of spillway apron.

Extensive model studies on both the hearth and bucket type basins and their combinations were made. It is well known that with the hearth type stilling basins, the energy of the flowing water is absorbed considerably by creating a hydraulic jump on the hearth, thereby, substantially reducing its velocity. Whereas, in the upturned bucket type, with low tail water, the water jet is thrown away from the toe of the dam, without any appreciable loss of energy. In this latter case, the energy is dissipated by churning and by scouring out the rock on the channel bed for a number of years till a stabilising pool is formed to sufficiently absorb the energy. The DVC Board of Consultants after carefully examining the results of various model experiments, finally recommended, in view of economy, the use of an upturned bucket having a radius of 60 ft. Model experiments also indicated better flow conditions, eliminating most of the undesirable cross flow from the stepped spillway buckets with the channel bed lowered either to Els.317 or 310. The higher elevation has been adopted for the channel bed in the final design. A massive reinforced concrete training wall, 230 ft long, has also been provided between the tailrace and spillway channels to guide the high velocity spillway flow and also to prevent formation of cross currents, disturbing the tailrace discharges from the powerhouse.

The fifteen spillway blocks were made in three steps of five blocks each with bucket invert elevations at 321, 333 and 339 respectively (Ref. Drawing spillway—Plan and Elevation). Dwarf walls are provided to guide the flow at points of change in bucket elevations. Fifteen tainter type crest gates, each 40 ft. high x 41 ft long are provided at crest elevation 405 for flood control in each spillway block. Besides nine slide type sluice gates, each 10 ft high x 5 ft 8 in. wide and one modified butterfly type gate of the same size are provided in the body of the spillway with centre line at El.342.

The crest gates were fabricated in TEXMACO shops in Calcutta and the slide type sluice gates along with control equipment were supplied by M/S Bouchayer Viallet of France. Both the above gates are made from welded structural steel. The emergency sluice gate which will be operated by a 40 Ton overhead gantry crane from the top of spillway deck, was fabricated in the DVC Central Workshop at Maithon.

A drainage-cum-inspection gallery (11 ft x 6 ft), running about 5 ft above the foundation level, extends through the first 8 blocks, starting from the right end of the concrete dam. An operating gallery, 7 ft wide × 14 ft 6 in. high, has been located at El.357 for the operation of undersluice service gates. Provision of curtain grouting and drainage of the foundation has been made from the drainage gallery and also from the operation gallery for blocks having no lower gallery. In the latter case, the operating gallery functions as drainage-cum-operating gallery and the outlets for foundation and formed drains are also located in the same gallery.

One interesting feature about the concrete dam at Panchet Hill is that very few heavy equipment has been used in the earlier stages in its construction.

Portable mixers and two small batching plants were used for mixing concrete in the earlier stages. The maximum size of aggregates used was 3 inches. Aggregates were broken by two small Baxter type crushers and also by manual labour. Crawler cranes were used for placing concrete with 1 cu.yd. buckets. Even with this meagre equipment, the work had progressed admirably and an appreciable part of the work had been completed during this time.

Only since October 1957, the screening and batching plants along with the two 40 ton whirler cranes and the construction trestle bridge, released from the Maithon Project were used for the placement of concrete.

With arrival of the heavy concreting equipment, the speed of construction went up considerably. Mixed concrete from the batching plant was carried in 6 cu.yd. buckets, placed on diesel powered locomotives over the trestle bridge erected on the downstream slope of the dam. The two revolving cranes were used for placing concrete and erection of formwork. Estimated quantity of concrete for Panchet concrete dam is 343,000 cu.yds.

Four different kinds of concrete were used in the construction of the dam and powerhouse. For mass concrete, class 'A' type, with an average strength of 2,200 psi and maximum 6″ size aggregates was used. Class 'B' concrete with an average strength of 3,000 psi with 3″ maximum aggregates was placed on the upstream face of the abutment and on both upstream and downstream faces of spillway. This type has also been used around sluice openings and piers carrying heavy reinforcement. Class 'C' concrete with aggregates 1.7/8″ maximum size and 3,000 psi strength was used in reinforced slabs, beams etc.

Class 'D' concrete with $\frac{7}{8}$" maximum size of aggregate was used in heavily reinforced zone of beams, columns etc.

Analysis of Concrete Dam and Spillway. In the analysis of the stability of concrete dam an earthquake acceleration of 5 percent gravity applied horizontally was assumed.

With reservoir empty, the earthquake forces were assumed to be acting in an upstream direction, and with reservoir full, the inertia forces caused by the dam and the water were assumed to act in a downstream direction.

A wind load of 30 lbs per sq. ft. was assumed to act on vertical projections of all exposed surfaces and the same for unloaded bridges was taken as 50 lbs per sq. ft.

The factor of safety against sliding was computed from the formula:

$$F.S. = [f \Sigma v + rs_u A] \div H$$

Where, f = Coefficient of friction.
Σv = Sum of all vertical forces.
s_u = Ultimate shearing strength = 600 psi.
$r.s_u$ = Allowable shear, where r = 0.5.
A = Area of contact under study.
ΣH = Sum of all horizontal forces.

Maximum allowable pressure of rock = 20 tons per sqft.

Uplift. For undrained sections in masonry, or between masonry and rock, pressure was assumed to act over 100 percent of the area, and to vary as a straight line from 2/3 of full headwater pressure plus one-third of full tail water pressure at the upstream edge to full tailwater pressure at the downstream edge.

For drained horizontal sections in masonry, and for foundations having drainage provisions, uplift pressure was assumed as full head water pressure at the upstream face which reduces to tailwater pressure plus $\frac{1}{4}$ of the difference between the head water and tailwater pressures at line of drains and then further reduces to tailwater pressure at downstream face.

A tension not exceeding 5 psi has been allowed in concrete under normal condition of loading and when earthquake forces and/or wind were considered, the maximum tension in concrete was not allowed to exceed 25 psi.

Intake and Powerhouse. Two Intake blocks (Blocks 4 & 5) each 72ft long are located immediate upstream of the powerhouse and form a part of the non-overflow sections of the right abutment at the right end of the spillway channel. Each of these blocks are provided with shear keys at block joints and also at the downstream face for a height of about 30 ft above the foundation level. These shear keys will be thoroughly pressure-grouted at a later date after the dissipation of the heat of hydration of concrete. The shear keys will therefore rigidly connect the intake blocks with each other and to the adjacent blocks and will thereby prevent unequal settlement. Two steel lined penstocks made from plates of varying thickness ($\frac{1}{2}$" to $1\frac{1}{2}$") and having a diameter of 28 ft each are embedded in the concrete structure. These penstocks are the largest ever to be installed in India to date and were fabricated by the D.V.C. Central Workshop at Maithon. A 2"thick layer of cork mastic has been applied on the upper half of the steel liner over a certain length in the downstream end where the concrete cover is less than 6 ft thick. The steel liner has been designed to take the full design thrust in this area.

An expansion coupling connects the penstock for Unit No. 1 with the scroll case downstream.

Where the steel penstock has considerable thickness of concrete all round, the penstock liner has been treated as a thin cylinder under internal pressure and the surrounding concrete as a thick cylinder under internal pressure with free outer surface.

The transition sections for the intake bell mouth (without steel liner) has been treated as elliptical holes in thin plates and maximum compressive and tensile stresses computed by the formula given in "Engineering for Dams" Vol. II by Creager, Justin & Hinds.

All welded longitudinal joints in the penstocks were radiographed to detect defects in welding. Objectional defects were repaired. Cassium 137 was indented originally for radio active source. But as this could not be procured in time, radiography unit with Iridium 192 as radio active source was used for testing penstock welding.

The bell mouth structure to the penstock is projected about 14ft upstream from the vertical face of the intake blocks to provide necessary space for housing the stop log and service gate slots and also to provide transition space for the water passages.

To reduce the size and cost of the stop logs and service gates, the penstock intakes have been provided with 'Y' branches with a central pier in each opening [Drawing Ref: Section thru centre line unit 1 and Powerhouse General Plan & Section]. Trashracks are provided at the upstream end of each opening.

Two sets of steel stop logs comprising a total number of 10 sections (one set of five sections is required for each opening) have been provided for maintenance of service gates and penstocks. These stop logs have been designed for operation during dry season with maximum reservoir Elevation 410. These stop logs are provided with rubber 'J' seals and have been fabricated by the Central Workshop, Maithon.

Four fixed wheel service gates ($30' - 2\frac{1}{4}" \times 17' - 4"$), one for each opening, have been provided in the gate

slots. The two service gates housed in intake block 5, will be used as bulkheads for the second penstock till the future unit (Unit 2) is installed. These gates are operated by individual hydraulic hoists located in the hoist chamber at El.445 below the roadway deck. The two service gates for the first unit will be normally housed in the respective gate slots. For raising the gate under balanced pressure, the service gates will be "cracked—open 6 in. to fill the penstock.

During maintenance operations of the service gate, both the gate and the hoist will be lifted from the gate slot by an overhead gantry crane and will be housed in respective storage slots in Blocks 3 and 4 respectively. The service gates and hoists were supplied by M/S Waagner-Biro of Austria.

Panchet Hill Dam has an above-ground powerhouse with vertical elbow type draft tubes of the conventional design and is located downstream of the intake blocks on the right bank of the spillway channel. A natural depression in rock formation in this area determined the location of the powerhouse to minimise the cost of excavation and concreting.

Preliminary designs for Panchet envisaged the installation of two 20,000 kW units in an outdoor type powerstation. The present plan is to install a single 40,000 kW Kaplan unit with provisions for the installation of a second unit of the same capacity at a future date. Principal reasons for this are that, with the general growth of inter-connected power system, a substantial peaking capacity will be needed, and the future unit at Panchet Hill offers the most economical possibility. However, the installation of the second unit will not be possible unless another dam is built upstream with sufficient storage capacity to supply water for power generation for the second unit at Panchet. Construction of Aiyar dam unstream can only solve this problem.

The powerhouse structure has been analysed as rigid frames standing above the sub-structure, and is 174 ft 6 inch long × 64ft wide × 73 ft high. The control room and the office are located on the floor at El.347.67, spanning between the upstream floor of the powerhouse and the downstream slope of the concrete dam. The units are spaced at 72ft centres and the generator for unit 1 is supported on concrete barrel above El.333. To prevent formation of unsightly cracks in the concrete slabs and walls of the powerhouse, contraction and control joints have been provided at suitable locations. An overhead electric crane of 225 tons capacity with two main hooks of 112.5 tons each and 2 auxiliary hooks of 25 tons each has been provided. The approach to the powerhouse is made through the 35ft wide roadway berm at El.360 on the downstream slope of the main earthdam. This berm connects the yard platform in front of the powerhouse and leading to the service bay inside the powerhouse. The draft tube deck at El.360, which is just above the maximum tailwater level will house the transformer. Utmost care has been taken in the design to reduce the overall cost to the minimum in the design, by omitting unnecessary floor spaces.

The 56,000 B.H.P., 125 rpm vertical shaft Kaplan turbine has been supplied by NOHAB of Sweden.

The 47,060 kVA, 11000 volts, 125 rpm generator has been supplied by AEG of Germany.

The 225 ton capacity E.O.T. crane has been supplied by LITOSTROJ from Yogoslavia and the 55 mVA 11/132 step-up transformer was supplied by MARELLI of Italy.

The area meant for the future unit will be built for the present upto El.299.5, thus leaving blockouts for the future installations of turbine and scroll case. The draft tube outlets are kept closed by draft tube gates manufactured in DVC workshop at Maithon. The superstructure for the entire powerhouse will be completed in the first instance. The switchyard will be located downstream from the powerhouse, on the traingular plot of land between the tailrace channel and the original river bed.

During the excavation of the intake foundation, the existence of Garnetiferous-Mica-Schist band was exposed in this area. As a result, further exploratory drillings were carried out to determine the trend of this fault. This band, having a thickness varying from 10 to 15 ft near the surface and inclination of 45° to 60°, dips towards a north-easterly direction under the overlaying rock. It was also noticed that the thickness of the band increases with depth and reaches a maximum value of about 42 ft at a depth of 95 ft below ground level. This Garnetiferous material is pinkish in colour and has an extremely low shear resistance. The presence of this fault called for extreme care in the excavation of the foundation and also for special foundation treatment of this area. Where this Mica-schist band was exposed near the surface, a trench of about 18 ft deep was excavated to remove this material. The trench was then back filled with concrete, which will act as an arch transmitting loads from the intake blocks on to the adjacent rock abutments. As the overlaying rock in this area is highly laminated and fractured, consolidation grouting of this area has been carried out from the top of trench concrete and also from the top of foundation concrete in block 4 (Ref. Drawing—Consolidation grouting—shear zone).

At the time of excavation of foundation for the powerhouse blocks, this Schist materials has also been exposed in the location of unit 1 draft tube base. The base slab under the number 1 draft tube has been made sufficiently thick to provide for the variation in modulus of elasticity of the foundation between shear zone and natural rock.

Extreme care had to be taken during excavation to prevent under-cutting the rock slopes overlaying the shear zone. Free drainage of exposed top surface and also for the covered zone was provided to pre-

vent ponding and percolation into rock joints and to relieve development of hydrostatic pressure from the covered zone.

BASIC DATA OF DAM & APPURTENANT WORKS

(i) *Hydrology*

(a) Catchment area	4,234 sq. miles
(b) Mean annual rainfall	44.95 in. (Moonsoon period) for 63 yrs. (1891-1953) for Rhondia Catchment.
(c) Max. annual rainfall	63.98 in. (Monsoon period) for 63 yers. (1891-1953) for Rhondia Catchment.
(d) Max. observed flood	3,02,000 cusecs at Sudamdih (Drainage area 3404 sq. miles).
(e) Design flood	6,80,000 cusecs 1.5 Inglis flood.

(ii) *Reservoir*

(a) Top of Dam	El. 457
(b) Max. reservoir level (DESIGN)	El. 449
(c) Dead storage level	El. 392
(d) Normal water level	El. 410

(iii) *Storage Capacity*

(a) Total to max. reservoir level (El.449)	13,65,000 ac.ft.
(b) Total to dead storage level (El.392)	1,48,000 ac.ft.
(c) Total to top of gate (El.445)	12,14,000 ac.ft.
(d) Total to normal water level (E1.410	3,33,000 ac.ft.
(e) Storage for seasonal flow regulation (El.392 to El.410)	1,85,000 ac.ft.
(f) Flood reserved (El.410 to E1.445)	8,81,000 ac.ft.
(g) Reservoir area at maximum water level (El.449)	41,200 acres.

(iv) *Main Dam*

(a) Type of Dam	Earth dam and Concrete dam
(b) Total length of dam	8,362 ft.
(c) Total length of concrete dam	1,215 ft.
(d) Max. height of concrete dam:—	
(i) Above foundation	157 ft.
(ii) Above channel bed	140 ft.
(e) Length of Earth dam	7,135 ft.
(f) Maximum height of Earth dam:—	
(i) Above foundation	135 ft.
(ii) Above river bed	133 ft.
(g) Length of dikes	13,806 ft.
(h) Max. height of dikes	54 ft.

(v) *Spillway*

(a) Maximum discharge	6,34,300 cusecs.
(b) Maximum height:—	
(i) Above foundation	157 feet
(ii) Above channel bed	140 feet
(c) Average width of base (including bucket)	165 feet
(d) Width at top (Roadway)	32 feet
(e) Elevation of spillway crest	El. 405
(f) Type of gates	Radial
(g) Size and number of crest gates	15 Nos. (41 ft × 40 ft)
(h) Size and number of undersluices	10 Nos. (10 ft × 5 ft 8 in.)
(i) Discharge through undersluice (at H.W. El.445)	37,700 cusecs.
(j) El.of top of crest gates	El.445 (Highest flood storage).

(vi) *Power Station*

(a) El. of maximum power pool	El. 445
(b) Maximum tailwater E1.	El. 360
(c) Number and size of penstocks	2 Nos. 28 ft dia. each

(vii) *Power Plant*

(a) Powerhouse dimensions	174′-6″ × 64′ × 73′ (approx.)
(b) No. of generating units	1 × 40,000 kW 1 × 40,000 kW (future)
(c) Max. head on turbines	103 ft.
(d) Installed power	1 × 40,000 kW

(viii) *Transmission*

(a) 132 kV – 132 kV
(c) 33 kV – „
(b) 66 kV – „

The Problems of the Damodar Valley and the Aspects under Development

By N. S. IYENGAR,
Manager, Reservoir Operations, DVC

THE mighty rivers of Sindhu, Ganga and Jamna formed the very stage on which the Indian Civilization danced with mirth and prosperity for many centuries. The water resources of the rivers remained the main life line of all activities for a long long time. However, during the last few centuries the rivers were almost completely neglected with the result a steep decline in the prosperity set in and it was not long before the country was gripped in poverty. How dangerous a neglected river can become and how very useful the same river can turn out to be when properly cared for, is illustrated here by a case study of the Damodar river.

Compared with the mighty rivers of Sindhu, Ganga and Brahmaputra, the river Damodar is a tiny one. From its source in Chotanagpur hills to its confluence with the Hooghly it is only some 300 miles long. The total catchment area drained by this river is about 8,000 square miles which is only about 2.2% of the total catchment of Ganges upto Hardinge Bridge. Although it is such a small river, because it lies right in the path of the cyclonic storms from the Bay of Bengal which produce concentrated heavy rainfall, this river has frequently recorded floods of very high intensity. Compared with 1.7 million cusecs in Ganges (D.A. 361,000 sq. miles) and less than a million cusecs in Indus (104,000 sq. miles), flood discharge of the size of 650,000 cusecs has been recorded in the Damodar four times during the past fifty years and in fact the October 1959 flood would have a peak flow as high as 800,000 cusecs.

During the floods huge quantity of top soil is eroded all over the upper catchment and is carried down the river, the sand load being deposited along the river bed and the organic and other fine material remaining in suspension. The latter has great fertilizer value and whenever the flood waters overtop the banks some of this valuable silt is spread over the adjacent fields and yields bumper crops, but the portion so used is only a small part of the annual silt load. Thus the very valuable top soil is continuously being eroded all over the upper valley and most of it is being carried away into the Sea. This process has been going on for many years with the result that the agricultural produce of the upper valley has continuously decreased year after year.

Continuous deposition of sand in the channel bed has resulted in the river frequently overtopping its banks and even changing its course. Records show that in the 18th century the Damodar river used to join the Hooghly at Tribeni, some 40 miles upstream of Calcutta; in the early part of the 19th century the confluence moved down to opposite Falta point, some 30 miles downstream of Calcutta; and at the present moment more than 90% of the annual flow goes into the Mundeswari channel which joins the Rupnarain river. The sand and silt deposits of the Damodar has affected even the wide channel of the Rupnarain with the result that the inland navigation along this river was withdrawn during the early decades of this century.

Over the entire delta the river has spread fertile deposits of silt which has attracted agricultural inhabitants in great number as a result of which the region around Burdwan has been one of the most densely populated areas. Every now and then the floods of Damodar sweep over these areas and cause considerable loss of life and property. The one flood in 1943 caused a loss of property worth about Rs 8 crores as estimated then which would be more than Rs. 50 crores as per the present price levels.

Also during the process of changing courses the river has left many low spots with stagnant pools of water, an excellent breeding place for mosquitoes carrying one of the worst kinds of virulent malaria, Burdwan Fever as it is called, which takes a toll of thousands of lives every year.

As if these natural calamities are not enough sectarian interests keep on fighting with each other. Some want floods because of its silt laden water and so voice their cry against flood control. Some are interested in the sand and so vehemently oppose the soil conservation measures in the upper valley. Those who are anxious about the Calcutta Port make an emphatic claim that they want the big floods of the Damodar to flush the Hooghly channel but they forget that the uncontrolled floods of the Damodar bring in huge quantities of sand and silt which choke up the channels. All along the river course a number of tiny interests have cropped up who oppose changes affecting their riparian rights. On top of all this, there is a tendency to believe that flood control and irrigation projects should be deferred because they do not yield adequate return on the capital outlay. These criscross fights only provide the river an unchecked tenure of destructive activity.

The dangerous position caused by neglecting the

Damodar river during the past few centuries may be summarised as follows:

(i) The top soil all over the upper catchment is being eroded and most of it is being carried away into the sea.

(ii) The lower valley has continuously suffered due to changing courses of the river, incidence of a virulent type of malaria and frequent flood devastations.

(iii) The river channels in the lower valley are choked up with sand deposition which has affected the inland navigation and also the Calcutta Port.

(iv) Due to rapid decline in prosperity, sectarian interests have sprung up with consequent further deterioration in the region as a whole.

As compared with the above dangerous position caused by neglecting the river let us now see what has resulted by properly caring for the river during the past ten years after the DVC was formed.

(i) With the completion of the Maithon and Panchet dams considerable flood protection has been assured. Only last year in September, 1958 a major flood with an unprecedented peak discharge of 665,000 cusecs occurred which was controlled to about 200,000 cusecs—well within the safe discharging capacity of the river channel in the lower valley. This year in October, 1959 a flood with a peak flow of 800,000 cusecs occurred which was controlled to about 350,000 cusecs.

(ii) The four reservoirs already completed will supply enough water for the kharif irrigation of one million acres in the fertile delta around Burdwan. In fact, in the 1958 season 5 lakh acres were already irrigated yielding bumper crops. This year in the 1959 kharif season it is reported that about 8 lakh acres are brought under irrigation.

(iii) The stagnant pools around Burdwan have been drained out and the incidence of malaria has been completely controlled.

(iv) The main irrigation canal also provides along its length of 85 miles facilities for inland navigation from the Hooghly upto the Durgapur Pond.

(v) All the sand charge brought down by the Damodar and the Barakar rivers is completely trapped in the Panchet and Maithon reservoirs thus saving the river channels in the lower valley from further deterioration.

(vi) Considerable quantity of sand will be stored in these reservoirs which can be used in the nearby coal mines for stowing purposes.

(vii) The water stored in the reservoirs is used for generating the valuable peaking power. The Maithon and Panchet hydel stations together can meet 100 mW of peakng demand and supply some 250 million kWhrs annually.

(viii) The water released from the dams is used for cooling purposes in the thermal stations at Bokaro, at Chandrapura and at Durgapur; it is used by many industries at Bermo, at Sindri, at Disergarh, at Kulti, at Burnpur, at Raniganj and at Durgapur; and it is also used for drinking water supply by Jharia Water Board, Asansol Municipality, Durgapur and other industrial townships.

(ix) The two basic requirements viz., the assured water supply and the abundant cheap electric power generated at the pithead thermal stations having been made available by the DVC, a number of heavy industries have been started to develop the vast mineral wealth of the valley. The electric power generating capacity serves as an index of industrial activity. Judged by this standard, the 400 mW installed capacity added by the DVC during these ten years gives an idea of the increase in the industrial activity in this region.

(x) With the multifarious development activities started in the valley, an unprecedented employment opportunity has been created both in the industrial and in the agricultural spheres which is creating a new prosperous society in this region.

The above list of benefits already achieved shows how prosperity has dawned in this region as a result of properly caring for the river. Yet plenty of work remains to be done before we get the maximum out of the river and our future programme may be broadly grouped as follows:

(i) Within the next ten years the dry period water demand will rise to 3300 cusecs whereas with the present four dams only 1300 cusecs can be assured. In order to meet the deficit of 2000 cusecs, it is necessary to take up immediately the construction of Aiyar and Balpahari dams.

(ii) Very little has been done to prevent the erosion of top soil in the upper valley. This should be tackled by a systematic extension of minor irrigation schemes.

and (iii) The problems of the trans-Damodar area in the lower valley should be studied with reference to the post-dam conditions and its potential for inland navigation and for extension of irrigation should be developed.

Inspection and Quality Control in Panchet Dam Construction

By B. B. CHATTERJEE,
Inspection Engineer, Panchet.
& By S. R. S. Rao,
Assistant Engineer, Panchet.

THE Inspection Wing as at Panchet Dam is provided to ensure satisfactory work in accordance with plans and specifications and with good engineering practice. It is a liaison between design and construction organisations. In big construction works there are likely chances of committing mistakes and omissions, due to oversight or slips on the part of the construction forces, more so, when they are forced to adhere to a tight schedule. Competent inspection prevents such mistakes and omissions by detecting them in time, thus saving both extra cost and time which otherwise would have been necessary to rectify the same at a future date. The Constuction Wing thus can devote with profit, much of their attention to other problems like procurement of materials, construction planning, pogress of work, labour poblems and payments etc. leaving safely the responsibility of quality control in the hands of Inspection. It helps in speedy solutions of problems arising out of field conditions not anticipated earlier. So Inspection being such a highly responsible job, it is but natural that it should be manned only by experienced and responsible personnel. The cost of competent Inspection is relatively little compared with the resulting insurance of quality and also with the cost of the structure.

ORGANISATION

The Inspection Wing at Panchet Dam Project functioning from the beginning was headed by an Inspection Engineer, who was fully responsible for the field inspection and was placed under the technical control of the Resident Engineer, M/s. Harza Engineering Company, Chicago, the Consulting Engineers for Maithon and Panchet Projects. The Inspection Engineer was assisted by a number of Inspectors inspecting the various works in each shift. A Research Officer under the technical control of the Inspection Engineer, was responsible for the performance of routine tests of samples and materials before and during construction, and their submission to the Inspection Engineer. The Research Officer under the direction of Inspection Engineer was also incharge of investigation and assessment of materials.

HOW INSPECTION IS CARRIED OUT

(1) *Concrete Dam Construction*

In general, the Inspection of concrete dam and power house constructions includes the followings:

(a) Examination of foundation and its approval:
The approval of the foundation is accorded by the Inspection Engineer. But the Inspector has to keep a watch while the excavation is in progress whether the same is done as per drawing and to make note of points of water percolation and other relevant features.

(b) Examination of form work:
The Inspector has to approve the form work at every stage before the placement of concrete. He has to check the form work for its alignment, structural stability, rigidity, mortar-tightness, smoothness and cleanness and proper treatment with suitable form-oil.

(c) Checking of reinforcement and embedded parts:
Reinforcement is checked for size, bending, spacing location, firmness of placement and surface condition. The embedded parts such as copper-water stops, anchor bolts, drain pipes, electrical conduits etc. coming in each lift in any particular block is checked for its position, size and rigidity.

(d) Concrete placing:
The Inspector has to approve the surface prior to placing the concrete, after the removal of laitance and thorough cleaning. He has to watch that concrete placing is done in an approved manner to avoid segregation and cold joints. He has to ensure that the mix coming is of right consistency and is vibrated thoroughly so as to fill all parts of the form work, eliminate air and rock pockets. The frequency of the vibrator is checked occasionally to see that it does not fall below the specified value. As the placing and vibration of the concrete is the key point of the whole operation of concreting, the Inspector has to keep a thorough watch over these operations.

(e) Curing, protection and removal of forms:
The Inspector has to see that the concrete surface is kept continuously damp for the specified period after placing, and protected against any damage due to removal of forms or due to loading before the specified period.

(f) Material Inspection, routine tests and mix design:
These items of works are carried out by the quality control wing, under the direction of the Inspection Wing in order to maintain good quality of work.

(g) Preparation of records and reports:
The Inspector is responsible for proper maintenance of records of works done in his shift and their submission to the Inspection Engineer. The Inspection Engineer compiles them in one daily report showing the progress of all works done in the whole project and submits the same to the Resident Engineer, Harza Engineeing Co., under intimation to the Superintending Engineer of the Project.

(2) *Earth Dam Construction :*

The following inspection procedure is generally adopted:

(a) Foundation preparation:
The Inspector has to ensure the foundation preparation such as stripping of top surface to remove all loose soil or boulders and other organic matters or cleaning of foundation trench, as the case may be.

(b) Borrow Area:
The Inspector keeps a constant vigil on the borrow areas to see and insist on proper stripping, watering and flagging of each dumper load for proper identification of different types of material.

(c) Embankment:
The Inspector checks that proper materials are dumped in impervious and semi-pervious zones, and spread to specified thickness, watered to optimum moisture, harrowed and rolled to specified compaction. The compaction attained is checked by visual inspection and proctor-needle. He inspects that the faces of the embankment are trimmed to proper slopes as shown in drawings, and that the riprap and wrap-around works, d/s filter at the toe of main earth dam are done as per design and specifications and with approved materials.

(d) Tests and reports:
The routine tests of materials and soil samples from the embankment are generally carried out by the quality control wing, but the Inspector keeps a constant watch over the test results to see that they are within the permissible limits. Tests like determination of moisture content, optimum moisture content by proctor's standard test, compaction, dry density by core cutter method or sand method, are carried out in the field laboratory. At the Main Laboratory the tests like determination of shear strength, permeability, plasticity index, and mechanical analysis are carried out. The Inspector prepares shift reports showing the works done in his shift and submits them to the Inspection Engineer, who incorporates these in the main report, submitted to M/s. Harza Engineering Co., under intimation to the Superintending Engineer of the Project.

(3) *Inspection of Steel-Structures :*

The Inspection of the fabrication and installation of the steel structures which were manufactured locally, such as penstock liners, undersluice emergency gate and guides, spillway bridge girders etc. were thoroughly carried out by the Inspection Wing. The Inspection of the installation of the steel structures manufactured at foreign firms, such as undersluice gates and liners, intake gates and guides etc. were also carried out by the Inspection Wing to check that they were erected within the prescribed tolerances; while the fabrication of the same was inspected by Indian Stores Department, London.

QUALITY CONTROL OF CONCRETE

The objective of quality control is to obtain a concrete which is uniform and of adequate quality for the service at minimum practicable cost. The uniformity of the structure is most important because its overall performance will be governed by its weakest portion. This object is attainable only through close and systematic control of all operations right from the selection of materials to completion of the curing of concrete. Such control is effected through competent inspection and testing staff. Much of the potential value of first class materials and optimum proportioning may be lost through ineffective control. It must be remembered that both good concrete and bad concrete can be produced from precisely the same materials and at the same cost. Hence it can be seen that control governs the quality, uniformity and ultimate economy of concrete.

The essential factors in the proper control of quality are as follows:

(i) Material control: testing and selection of ingredients like coarse aggregate, sand and cement.

(ii) Batching plant Inspection: checking of the various aggregates and cement scales, wattmeters and production graph recorders for adjustments.

(iii) Field testing: testing of mixed concrete for consistency, unit weight, air content and compressive strength. Coarse aggregate is tested for grading analysis, unit weight, specific gravity. Fine aggregate is tested for fineness modulus, moistrue content, bulk density etc.

DIFFERENT MIX PROPORTIONS USED DURING CONSTRUCTION

Right from the commencement of concrete dam upto middle of May 1957, the concrete was produced by a 2 cyds. capacity batching plant. This batching plant had only two coarse aggregate chambers and no arrangement for screening and mixing more than two sizes of aggregates together. Hence the grading of coarse aggregates was not uniform for all the batches of mix. This defect was improved by taking the grading analysis from time to time and adjusting the mix accordingly. The maximum nominal size of coarse aggregate used was 3″ obtained from a Baxter crusher. In addition to the above plant, the concrete was also produced by an electric mixer using volumetric proportions.

CONCRETE MIX PROPORTIONS (lbs/cyds)
OLD 2 CYDs. BATCHING PLANT
Nominal Max, size of Agg. 3″

Class	Baxter Crusher—Agg. (unscreened)	2″ Agg. (hand broken)	1″ Agg. (crusher run)	Sand (dump)	Cement	Water	W/C	Strength at 28 days (p.s.i.)
A—1	—	2000	770	870	400	260	0.65	2200
A—2	2200	—	560	850	350	210	0.60	2200
A—3	2000	700	—	910	370	218	0.65	2200
B—1	—	2000	770	800	480	264	0.55	3000
B—2	2200	—	560	850	450	227	0.55	3000
C—1	—	1½″ (hand broken) 1610	760	1020	525	235	0.50	3000

Note:— (*a*) 2″ aggregate contained about 11% of sand size rock-dust which was taken into consideration in cutting down the river sand. The batch weights were changed whenever the proportion of rock-sudt contemination changed.
(*b*) Water measure was changed to suit the moisture content of sand and evaporation conditions.
(*c*) Whenever Vinsol-resin (air-entraining agent) was used at the rate of 40 gms. power per cyd. (800 c.c. by Vol. of the stock solution of 5% strength) water was reduced by 16 to 20 lbs. and cement was reduced by 25 lbs.

By middle of May, 1957 the 9 cyds. batching plant from Maithon was installed and put into operation. The following were the mix proportions used, for different types of concrete in terms of lbs/cyd (clear separation basis).

VOLUMETRIC PROPORTIONS USED IN ELECTRIC MIXER
IN TERMS OF cft/cyd

Class	Baxter Crusher Agg. (unscreened) 3″ size. cft.	1½″ Agg. (hand broken) cft.	1″ down (crusher run) cft.	Sand cft.	Cement bags	Water gals.	W/C	Strength at 28 days (p.s.i.)
A—2	22	—	5.5	10	3.25	21.0	0.66	2200
B—2	22	—	5.5	10	4.25	23.0	0.55	3000
C—1	—	16	7.5	12	5.00	23.5	0.50	3000

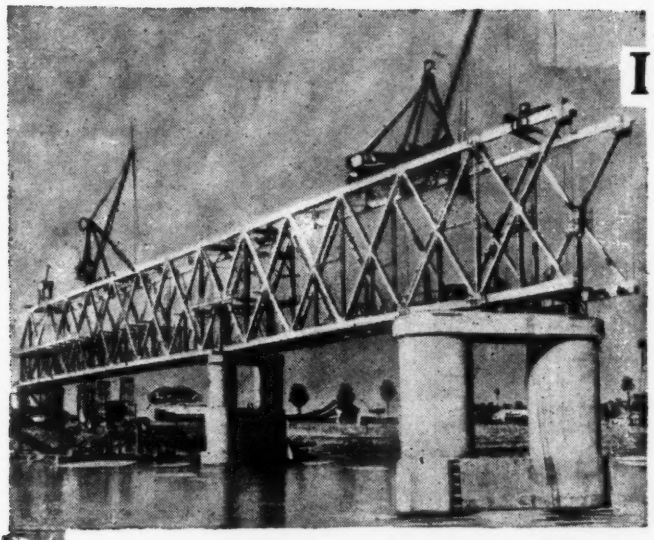
Note:—(*i*) 1 bag of cement—110 lbs.
(*ii*) The proportion of sand, aggregate and water requires adjustment according to field conditions of sand and aggregates.

9—CYDS. BATCHING PLANT MIX
PROPORTIONS (lbs/cyd)

Ingredients	A_1 type	A_2 type	B type	B(Special)	C type	C(Special)
6″—3″	1250	1100				
3″—1⅞″	300	500	790	970		
1⅞″—⅞″	1000	800	1170	845	1180	1290
⅞″—¼″	150	300	240	605	720	850
Sand	900	900	1200	1015	1400	1080
Cement	300	300	410	445	500	545
Water	210	210	240	263	270	310
60 days strength required (p.s.i.)	2200	2200	3000	3000	3000	3000

Note :— (1) Vinsol resin used as air entraining agent at the rate of 32 to 40 gms/cyd. (5% solution).
(2) Proportion of fine and course aggregates on the basis of clean separation.
(3) Minor adjustments to be done according to field condition.
(4) Mix-design based on 60 days strength.
(5) Special mixes of B & C class concrete were designed to place below the penstock liners, and were also used in Power House structures later on where the reinforcements were too closely spaced.

(Continued on page 14)



INDISPENSABLE

For use in concrete under water and for heavy load machineries. Also prevents Saltpetre action, dampness of the structure.

WATERPROOFING COMPOUND.

RELA

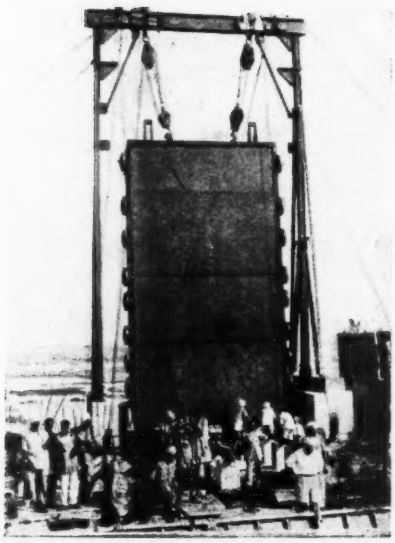
THE CEMENT RESEARCH CORPORATION.
15, GOVINDA BANERJEA LANE,
CALCUTTA-33

CPM/C/2

WAAGNER-BIRO

AKTIENGESELLSCHAFT

WIEN GRAZ



PLACING OF A TURBINE INTAKE GATE AT POWER STATION, PANCHET HILL, BENGAL. SIZE OF LEAF: 5×9M. WEIGHT 31 t.

We ARE SUPPLYING SLUICE GATES FOR RIHAND DAM AND TURBINE INTAKE GATES FOR

- BHAKRA
- PANCHET HILL
- HIRAKUD
- GANDHISAGAR
- KOYNA

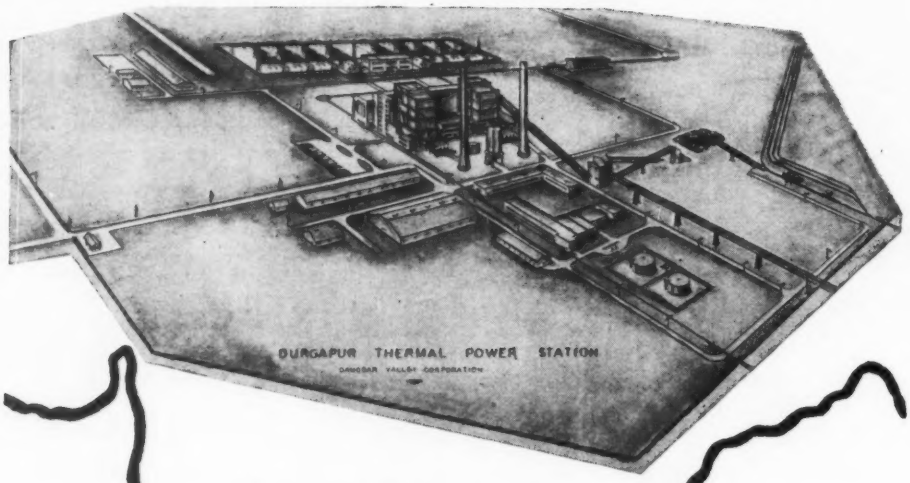
MARSHALLS

MARSHALL SONS & CO (INDIA) LTD.

33/1 NETAJI SUBHAS ROAD, CALCUTTA
BOMBAY • MADRAS • NEW DELHI

MS/EAA

India's POWER



In Durgapur—work on another gigantic steam power station is now underway. Being of the economical semi-outdoor type, the project represents not only the latest in power plant design, but is also the second major station to be built by the Damodar Valley Corporation within recent years.

The new plant is scheduled for initial operation in 1960, and will consist of two 75,000 KW units, with a maximum capacity of 165,000 KW.

As Consulting Engineers to D. V. C., The Kuljian Corporation was charged with engineering and construction supervision of the entire project. . . .serving as an excellent, and continuing example of India's Power Project Authorities' confidence in the Kuljian Services.

The Kuljian Corporation

engineers • constructors

1200 North Broad Street • Philadelphia 21, P.A., U. S. A.

BRANCH OFFICES THROUGHOUT THE WORLD

INDIA OFFICE : 7, CHITTARANJAN AVENUE, CALCUTTA.

Consultants in India for:

Bokaro Thermal Power Station, D.V.C.
Durgapur Thermal Power Station, D.V.C.
Bokaro 4th Unit Extension, D.V.C.
"C" Station, Delhi Electric Supply Undertaking.
Barauni Thermal Power Station, Bihar.
Durgapur 120 MW Extension, Govt. of West Bengal.

Power Development of the DVC

by S. BOSE,
Addl. Chief Electrical Engineer, DVC.

THE DVC has at present the largest integrated power system in the country with installed generating capacity aggregating to 254 mW comprising three 50 mW units at Bokaro Thermal Power Station, two 2 mW units at Tilaiya Hydel Station, three 20 mW units at Maithon Hydel Station and one 40 mW unit at Panchet Hill Hydel Station (which has gone into commercial operation in Septemper 1959), and a transmission system comprising seventeen 132 kV substations, fifteen 33 kV receiving stations, 713 miles of 132 kV and 91 miles of 33 kV transmission lines, spread over a large area in West Bengal and Bihar.

Due to mounting power demands in this area, which is the industrial belt of India, generating capacity and transmission facilities of the DVC system need to be continuously augmented and power projects under execution are briefly detailed here. Shortage of water on account of heavy demands for irrigation and industries has laid emphasis on thermal power generation which can be provided economically by installation of large thermal generating units using low grade coal available in abundance in the Valley. Secondly, a sizeable hydel project takes longer to construct and the thermal generation projects now under execution have been undertaken with a view to meet the present acute power shortage in the shortest possible time.

Thermal generating plants in advanced stages of construction are two 75 mW units at a new power station at Durgapur and one 75 mW unit as extension to the Bokaro Thermal Power Station. These are single turbine-single boiler installations for operation with 1450 p.s.i. 1000°F steam at turbine throttle.

DURGAPUR THERMAL POWER STATION

The Durgapur Thermal Power Station, sited near the Oyaria Railway Station of the Eastern Railways about 100 miles north-west of Calcutta, will have initially two 75/82.5 mW thermal generating units with provision for future extension by two more units of larger capacity.

The turbines are rated at 75/82.5 mW at 1450 p.s.i. steam pressure, 1000°F steam temperature at the throttle and an exhaust pressure of 1.7" of Hg. absolute. The turbines are of twin cylinder impulse type, the high pressure casing arranged for single flow and the low pressure casing for double flow, with five extraction stages. The generators are each rated continuously for 75 mW with hydrogen gas pressure of 0.5 p.s.i. and for 82.5 mW with hydrogen gas pressure of 15 p.s.i., both at 13.8 kV 0.85 power factor 3000 rpm. The main exciter is directly coupled to the generator shaft and the field of the main exciter is excited by an amplidyne mounted on the exciter shaft.

The boilers for outdoor installation are of the dry bolton type with U flame burners having 330 tons per hour normal continuous rating and 340 tons per hour peak rating for four hours, while operating at 1500 p.s.i. pressure and 1005°F temperature of steam at superheater outlet. The furnaces are suitable for burning pulverised coal, middlings and/or coke oven gas. Each boiler is provided with two Ljungstrom air preheaters, two double speed induced draft, two constant speed forced draft fans and four coal mills including one standby.

The condensers, each having a surface area of 65000 sq. ft., are of two pass dual bank divided water box surface type, complete with a set of reverse flow nozzles to keep the condenser tubes clean and a deaerating hotwell specially designed to produce condensate having free oxygen not exceeding 0.01 cc/litre. Each condenser is provided with two full duty condensate pumps, two circulating water pumps, twin element two stage steam jet air ejector.

Each generating unit is provided with two vertical high pressure, two horizontal low pressure heaters, one deaerating heater, and three feed pumps (each of half capacity, two with direct coupling and one with hydraulic coupling).

The plant is provided with automatic combustion control, superheat temperature control, feed water control in addition to standard electrical control and protection. The furnace flame and drum water level will be televised on the control panel.

The electrical system comprises generators directly connected each to its 100 mVA 13.8/138 kV OFW type step-up transformer, which is in turn connected to the 132 kV bus through disconnecting switches and 3500 mVA circuit breakers. The Durgapur switchyard will be connected to the DVC 132 kV grid by diverting the existing 132 kV double circuit lines between Kalipahari and Burdwan substations via the power station. Local power supply to the Durgapur Steel Plant will be made through two 50/40/12.5 mVA 138/33/3.15 kV transformers.

Cooling water to the power station will be taken from the Durgapur barrage through a low level canal (common for the power station, Durgapur Steel Plant

and Durgapur Industries), a pump house on the canal near the power station and two 2000 ft. long 60 in diameter steel pipes. The canal will bring a flow of about 800 cusecs for the power station, of which only about 300 cusecs will be required for the present 2-unit installation.

The main fuel for the boilers will be middlings (1000 tons per day) from the coal washery of the Durgapur Steel Plant and 22600 cm per hour of surplus coke oven gas from the steel plant. The supply of gas might taper off in future years and at that time the boilers will burn in addition raw coal from the neighbouring collieries. The coal handling plant at the power station has been so designed that it can handle the present requirement as well as the future requirement by working extra hours.

A multiple tube cyclone type fly-ash collector will be installed with each boiler. Provision has been kept for future installation of electrostatic precipitator.

The power station is so designed that its basement is at ground elevation with an elevated turbine operating floor. The turbine room will be serviced by a 150 ton electric overhead travelling crane.

The generating units have been arranged along the longitudinal axis of the power station, the control room housing all boiler and turbine control, turbine supervisory instruments, control panels for soot blowing, etc., being located in between the two turbo-generators on the boiler side.

The capital cost of the station is expected to be about Rs. 13.25 crores, which works out to Rs. 883 per kW installed on the basis of aggregate capacity of 150 mW although the maximum rating aggregates to 165 mW.

BOKARO FOURTH UNIT

The fourth unit at the Bokaro Thermal Power Station is identical in all respects to the generating units being installed at Durgapur Thermal Power Station except that

(i) the boiler is designed for indoor installation and for burning low grade coal from the nearby mines, including also middlings from Kargali Washery. (There is no provision for burning coke oven gas.)

(ii) the turbo-generator operating floor is at ground level, the condenser etc., being in a dry pit.

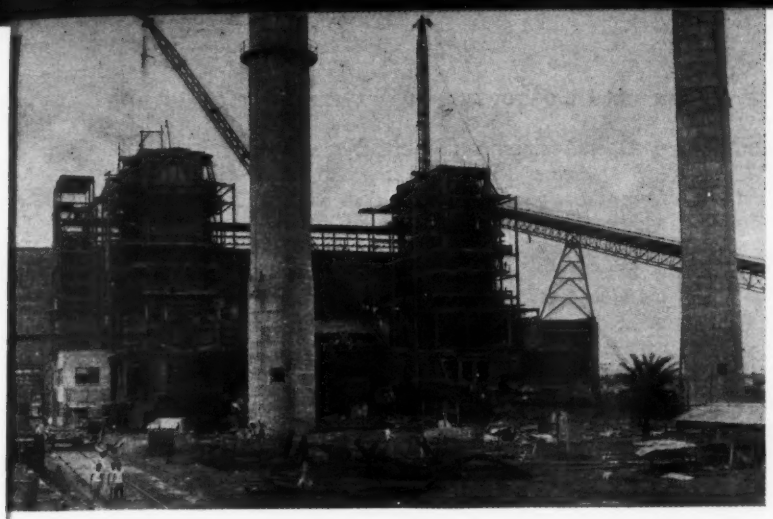
(iii) while the turbo-generator has been placed on reinforced concrete foundation at Durgapur, the turbo-generator at Bokaro has been placed on steel foundation.

CONSTRUCTION ORGANISATION

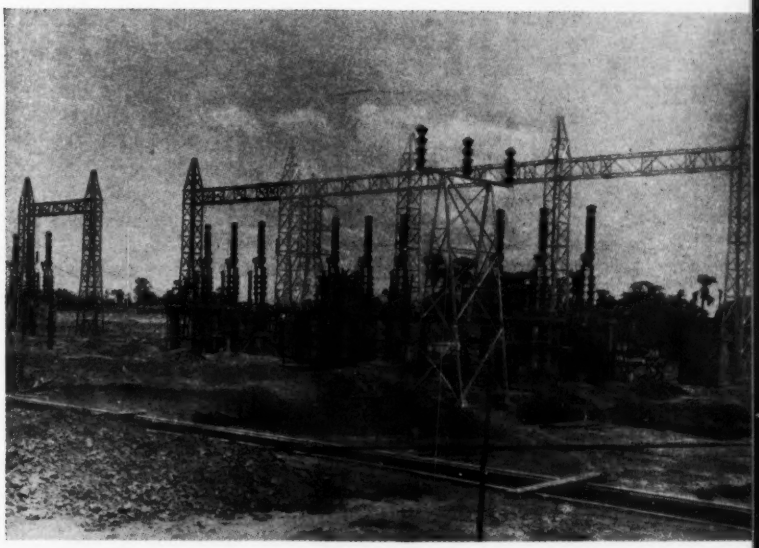
As these are the largest single boiler—single turbine installations with high pressure and high temperature steam in this country, it was considered advisable that the responsibility for design and construction management should be entrusted to a firm of Consulting Engineers and the services of M/s. Kuljian Corporation, Philadelphia, USA have been engaged for the purpose. At the same time, the undesirability of complete dependence on foreign technical assistance and the need for achieving self-sufficiency was borne in mind and as a step towards this objective it was decided that while design and construction management for Durgapur Thermal Power Station should be entrusted to Kuljian Corporation, the work of design and construction management for Bokaro fourth unit would be undertaken departmentally by the DVC, under direction and guidance of Kuljian Corporation. These two thermal projects are currently under construction on the above basis. The preliminary site works at Durgapur Thermal Power Station started in the third quarter of 1956 and plant construction work commenced in May 1957. Delay in delivery of plants and certain other unforeseen difficulties have caused setback to the scheduled commissioning of this station and on the basis of up-to-date schedule, the first unit at Durgapur is expected to be ready for commissioning about the end of March 1960 and the second unit about the end of June 1960. The fourth unit at Bokaro Thermal Power Station is expected to be in commission by about the end of February 1960. Design and installation of the existing Bokaro Thermal Power Station with three 50/57.5 mW units with steam at 850 p.s.i. pressure and 900°F temperature at throttle was carried out under complete supervision, direction and management of M/s Kuljian Corporation of U.S.A. This large project formed the training ground of a team of DVC engineers whereby the DVC built up an organisation adequately experienced to take up the operation and maintenance of the Bokaro Station which was then the largest station in the East. This also provided facilities for a number of DVC engineers to acquire considerable experience in design and construction of large thermal power plant. The Durgapur Thermal Power Station and the fourth unit at Bokaro, now under construction, constitute a step forward with more modern design features, adoption of higher steam conditions, single boiler-single turbine installation and above all the opportunity to DVC engineers to bear increased responsibility in the design and construction management, which has been more so in respect of Bokaro 4th Unit.

CHANDRAPURA THERMAL SCHEME

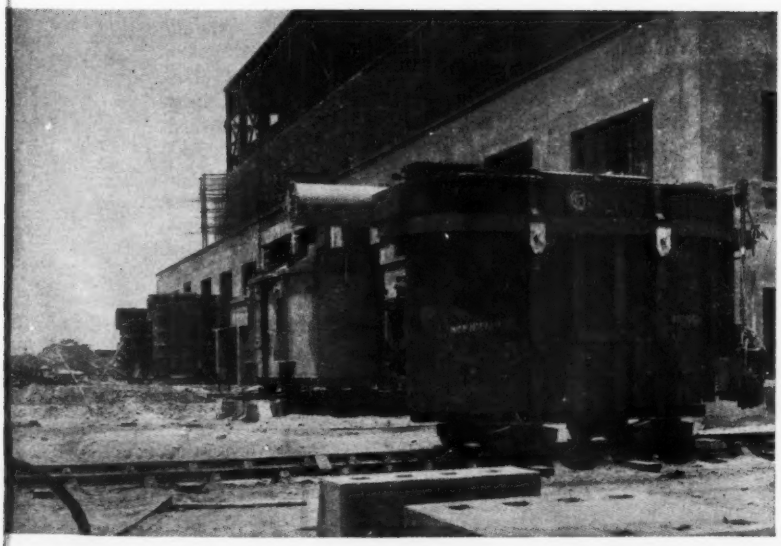
A bolder progressive step has now been taken by the DVC in respect of the Chandrapura Thermal Scheme involving design and installation of one single boiler—single turbine 125/140 mW reheat unit. The size and design features of this unit are not only far ahead of what has been so far contemplated in our country but are comparable to the up-to-date



Durgapur Thermal Power Station under erection.



Outdoor Switchyard at Durgapur Power Station.



Transformers at Durgapur Power Station.

trend of power development in advanced countries in the West. The bold step taken by the DVC towards achieving technical self-sufficiency is evident from the fact that all the work of engineering, design and construction management of this large and modern thermal unit will be done departmentally and only direction and guidance will be given by a firm of Consulting Engineers M/s. Gibbs & Hill of U.S.A. The design features and plan for this power station, details of which have still to be finalised, are indicated as follows:

The power station will be sited close to the bank of the Damodar river and at a location near the Chandrapura Railway Station of the Eastern Railways about 200 miles west of Calcutta and about $1\frac{1}{2}$ miles from the Dugda Coal Washery of the Hindusthan Steel Ltd., now under installation.

The power station will have initially only one 125/140 mW reheat unit with steam at 1800 p.s.i. pressure and 1000°F/1005°F temperature at throttle and provision will be made for adding some more similar or larger units in future. The boiler of the dry bottom type suitable for outdoor installation is rated at 960000 lbs. per hour with steam at 1900 p.s.i. pressure and 1005°F temperature at superheater outlet and steam at 1005°F temperature at reheater outlet. The generating units will be laid transversely, each set of 2 units making a block with a central control room housing all controls for boiler, turbine, generator etc. The machine hall will be serviced by a 75 ton electric overhead travelling crane. The generator stator which will weigh about 165-170 tons will be handled by means of the above crane in conjunction with lifting jacks etc. The contour of the location and the preliminary boring data indicate that the basement of the power station will probably be on ground level with elevated turbine operating floor. The generating unit will be solidly connected by means of isolated phase bus ducts to a 3 phase 165 mVA power transformer with 138 kV on the high voltage side. The Chandrapura 132 kV switchyard will be connected to the DVC grid by diverting the existing 132 kV d/c transmission line between Bokaro and Putki.

The boiler for the first unit will burn middlings and rejects from the adjacent Dugda Washery conveyed to the power station coal yard by belt conveyor, where these will be blended in proportion, crushed and conveyed to the plant bunkers. Provision will also be made to unload in the coal yard railborne low grade coal from adjacent coal fields, which will supplement the supply from the washery as and when required. The present washery capacity will yield about 2171 tons (metric) of middlings and rejects per day with high ash content and low volatile. There is definite plan for doubling the washery capacity in the near future in which even the fuel requirement for the second extension unit can be met from this source.

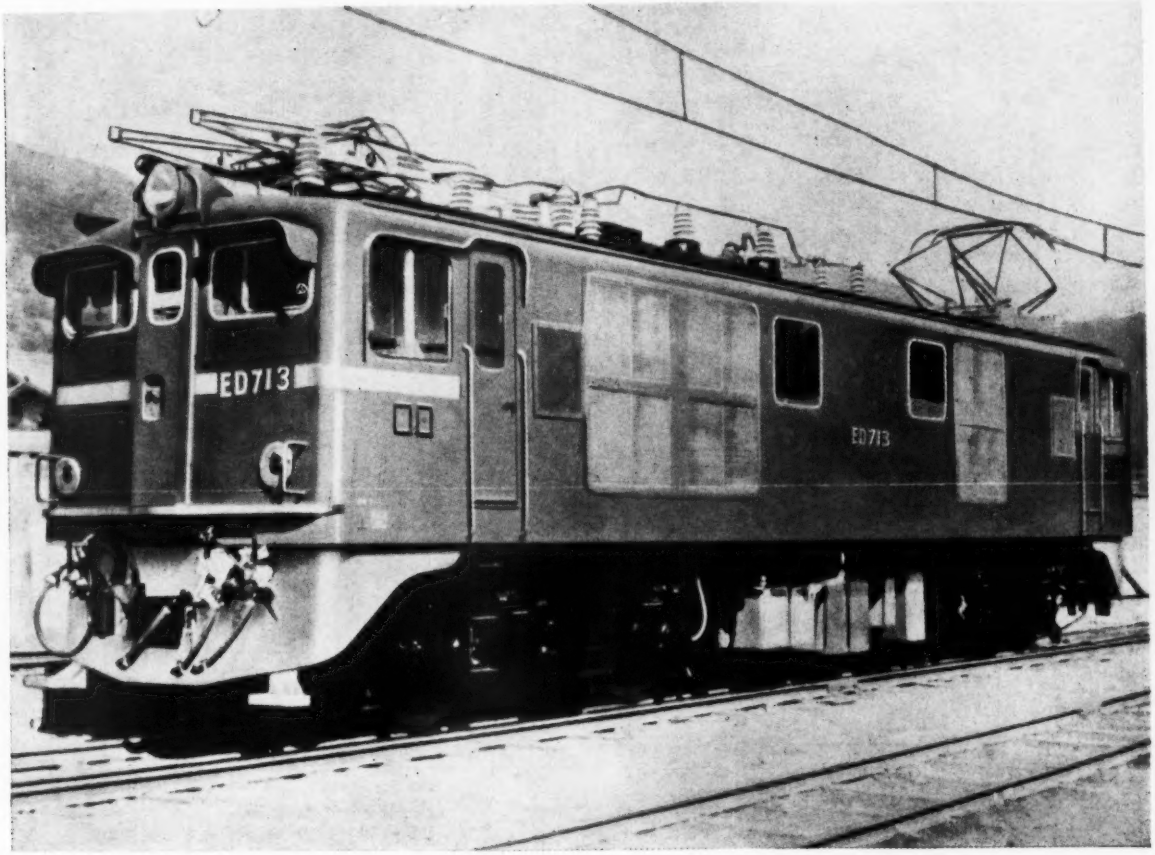
Assured minimum flow of 300 cusecs in the adjoining Damodar River resulting from the discharge from the upstream Konar dam is insufficient for adoption of natural water circulation through the condenser for cooling purposes when more than one unit is considered at Chandrapura. Cooling towers will therefore be provided and the small quantity of make-up water will be pumped from the river bed by installing pumps in intake wells. If and when Aiyar dam is constructed and a barrage is built upstream of Chandrapura site for Bokaro Steel Plant, it might be possible to adopt natural circulation or mixed cooling system for the future extension units, depending of course on the assured flow and the requirement by the Bokaro Steel Plant.

The power house, except the boiler structure and steel trusses and purlins to support the roof, will be constructed of reinforced concrete. The roof itself will be of light-weight precast concrete slab design. Plans for colony, access roads, temporary facilities of water and electricity for construction camp have been finalised and construction of these works will be in active progress from November this year. Technical specifications of a number of plant and equipments are nearly complete, those of the steam-generator and turbo-generator were completed and issued some months ago and orders for the same are expected to be placed early November this year. According to present plans, the unit is expected to be ready for commission by about the end of 1962.

TRANSMISSION FACILITIES

In regards to transmission facilities for utilizing the additional generating capacity as above, augmentation of sub-station capacities at Maithon, Jamshedpur, Gaya, Patna, Sonenagar, Barhi, Ramgarh, Putki, Bokaro, Sindri is in progress and 106 miles of double circuit 132 kV and 110 miles of single circuit 132 kV transmission lines and coversion of 194 miles of single circuit 132 kV lines to double circuit are under construction.

Besides, a project of large magnitude is under execution involving design and installation of 7 new substations at Kumardhubi, Ramkanali, Chandil, Purulia, Kodarma, Nimiaghat and Kolaghat, extension of existing substations at Durgapur, Panchet Hill, Putki, Barhi, Gaya, Sonenagar, Mosabani, Kharagpur, Howrah, Belmuri, Burdwan, Gola and Jamshedpur and construction of 13 miles of double circuit 132 kV transmission lines and 43 miles of single phase double circuit 132 kV transmission lines, to supply power by the DVC to 25 kV single phase track electrification for Eastern and South-Eastern Railways. The estimated cost for the DVC's portion of this project is Rs. 4 crores approximately. It involves installation of ten 12.5 mVA and eleven 10 mVA 132/25 kV single phase power transformers, and asociated controlling and protective equipments on the 132 kV and 25 kV



22 KV MITSUBISHI ELECTRIC LOCOMOTIVE OPERATING
ON JAPANESE RAILWAY SYSTEM

Similar locomotives (10 Nos.) but suitable for 25 KV Traction
are being supplied by them for Indian Railways.

Manufacturers :

MITSUBISHI ELECTRIC MANUFACTURING CO. LTD., JAPAN

Export Agents :

MITSUBISHI SHOJI KAISHA LTD., JAPAN

Sole Selling Agents :

EASTERN EQUIPMENT & SALES LTD.

9, BRABOURNE ROAD,

CALCUTTA-1

NEW DELHI • BOMBAY • MADRAS • RANCHI

MARTIN MB BURN LTD

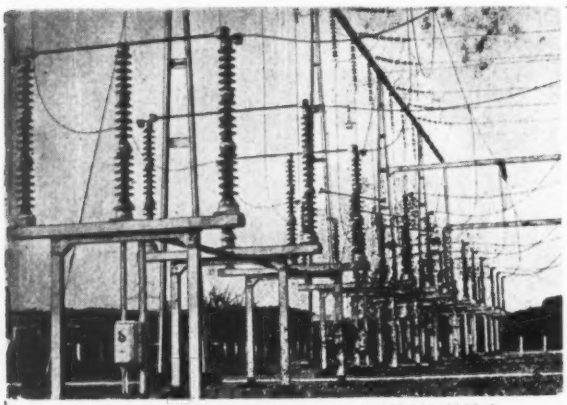
SELENIUM
SenTerCel
RECTIFIERS

Battery Chargers and AC/DC Conversion

Assembled in India by **MARTIN BURN LTD.**
For
Standard Telephones and Cables Limited

CALCUTTA
BOMBAY DELHI KANPUR

MCWC-1054



Isolators (Disconnecting Switches) 220 kV, 1000 A
with motor operated mechanism

We delivered for the Panchet Hill Power Station of the Damodar Valley Corporation all the outdoor isolators (disconnecting switches) for 33 and 132 kV.

In the same manner we have supplied many isolators for outdoor from 10—400 kV to several countries, with hand, electrical or pneumatic drives.

Use all our isolators with the most modern full body insulators, which cannot be punctured.

Other specialities of our firm are water loading resistances to test generators and outdoor connectors for pipes and cables.

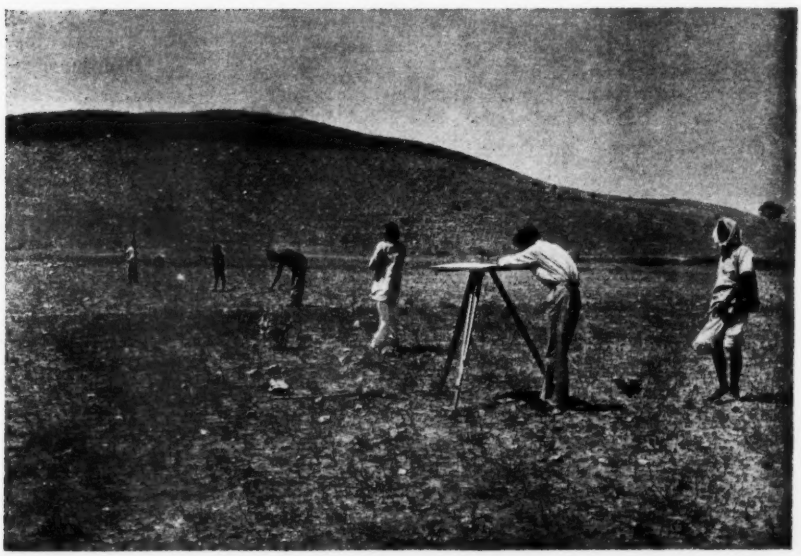
ALPHA LTD. NIDAU SWITZERLAND

side. The DVC will supply power to the railways directly at 25 kV at 11 substations and at 132 kV to the concerned State Electricity Boards at 7 substations who in turn will supply the railways at 25 kV. Procurement of plant and equipments is in progress and installation work will be taken in hand shortly with a view to meet the power requirement for track electrification of Burdwan to Gaya and Asansol to Rourkela sections scheduled for commission in June-September 1960. The balance of the Railway Electrification Scheme in question is scheduled for commission by the middle of 1961.

It may be emphasised that the DVC has full-fledged organisation to undertake departmentally the design and complete erection of substations and transmission lines and that all the works, indicated above are under execution departmentally.

Power development is a dynamic process, the tempo of which will have to be particularly great in this area where potentialities are very large. As such, the DVC is continuously engaged in the formulation and planning of new power development schemes to meet the fast increasing demand. To meet the immediate requirement, extension of Chandrapura and Durgapur Power Stations by addition of one 125/140 mW unit at each place has been proposed and a hydel scheme has been planned comprising installation of one 20 mW reversible pump-turbine unit at Konar Dam. Clearance has recently been given for addition of one 125/140 mW thermal unit and the remaining proposals are at present under consideration of the Government of India. Further addition of thermal generating capacity by installation of a number of 125 mW units has been proposed for the Third Five Year Plan. Certain hydel schemes such as addition of a 40 mW unit at Panchet Hill Power Station and provision of 100/120 mW generating capacity at the proposed Aiyar Dam are under active consideration by the DVC.

The future of power programme in this area, as can be visualised at this stage, may be the establishment of the Eastern Grid comprising DVC system of central thermal stations backed by hydro generation and interconnected with the power systems of West Bengal, Bihar, U.P. and Orissa.



Surveying at the site of Chandrapura Thermal Power Station.

Panchet Hill Hydro-Electric Power Station

S. B. DEB,
Project Engineer
Electricity Dept., DVC

THE Panchet Hill hydro-electric power station, having the largest capacity Kaplan turbine driven generating unit in India and the associated Panchet Hill dam and appurtenant works with the embankments form part of the unified development of the Damodar Valley in the eastern region of India. The completion of the Panchet Hill dam on the Damodar river with its power station marks the end of the first phase of development, the blueprint for which was prepared by Mr. Voorduin. Attempt has been made in this article to present a description of the power plant together with a review of the design and engineering problems studied to determine the various features of the power station and plant as have been incorporated.

GENERAL FEATURES OF PANCHET HILL PROJECT

The Panchet Hill dam with a drainage area of 4234 sq. miles has created a reservoir having a total storage of 1,214,000 acre-ft., comprising a dead storage of 148,000 acre-ft upto El.392.0, a live storage for irrigation and power generation of 185,000 acre-ft. upto El. 410.0 and a controlled flood storage of 881,000 acre-ft. upto El. 445.0. The project comprises the following works:

(i) 2722 ft. long rock-filled earth embankment on the original bed of the river.

(ii) 1215 ft. long concrete gravity dam forming the spillway section, abutments and intake blocks. The spillway section is provided with fifteen radial gates and nine undersluice gates. The concrete dam is constructed on the diversion channel, formed for diverting the flow during construction period.

(iii) 18218 ft. long earth dam and dyke, a portion of which has been designed to act as the breaching dyke.

(iv) power station and 132 kV switchyard.

The total expenditure for the project including the switchyard has been of the order of Rs. 17·91 crores, out of which the hydro-electric installation including the switchyard accounts for about Rs. 3.5 crores.

The 'Preliminary Memorandum for the Unified Development of the Damodar Valley' drawn up by Mr. Voorduin proposed installation of two 20 mW Francis turbine driven generating units at Panchet Hill power station, making a total installed capacity of 40 mW. Until the end of 1953 the planning of the power station was proceeding on this basis. A memorandum entitled "Ultimate Installed Capacity for Panchet Hill Power Station" was submitted by the Electricity Department of the Corporation to the DVC Board of Consultants, meeting at Maithon in February 1954, recommending that the ultimate installed capacity of the Panchet Hill power station be increased to 80 mW with an initial installation of one unit of 40 mW capacity (Kaplan turbine driven generating unit) and a future installation of an identical unit when the load growth warrants it.

The main reasons put forward in the above memorandum are:

(i) the flow in the Damodar river at Panchet Hill during the monsoon period (July-October) is abundant and limitation of station installed capacity to 40 mW would result in considerable spillage over the dam, which can be appreciably reduced by increasing the installed capacity to 80 mW.

(ii) increasing the installed capacity from 40 mW to 80 mW would add firm capacity of 30 mW to the DVC power system, which would assist in meeting additional load demands.

(iii) it would be possible to earn an appreciable net revenue due to the system being able to meet an increased load.

(iv) as a result of being able to generate more energy from the water during the wet period, which would otherwise have been wasted, there will be a considerable saving in the use of coal for power generation.

(v) by installing one unit of 40 mW capacity and providing space for the addition of the second identical unit in future, there will be a saving of about Rs. 10 lacs in the project cost.

(vi) depending on the general growth of the interconnected power system, a substantial peaking capacity will be needed and there appears to be no alternative where such capacity can be obtained more economically than at Panchet Hill.

The Board of Consultants reviewed the memorandum and after satisfying themselves that the general hydraulics of the peaking operation at Panchet Hill

THREE M. A. N. Boilers for Durgapur Thermal Power Station and Bokaro Extension—each 330 tons/hour capacity and 1450 lbs./sq. in. pressure.

THREE M. A. N. Turbines for Durgapur Thermal Power Station and Bokaro Extension—each 75/82.5 MW.

M. A. N. Coal handling plant for Durgapur Thermal Power Station.

ONE A. E. G. Hydro-Generator for Panchet Hill—47,060 kVA.

M. A. N. Under Sluice Gates, Tunnel Lining and Emergency Gate for Konar Dam.

IMPORTANT EQUIPMENT
SUPPLIED & ERECTED BY :

ESCORTS (AGENTS) PRIVATE LTD.

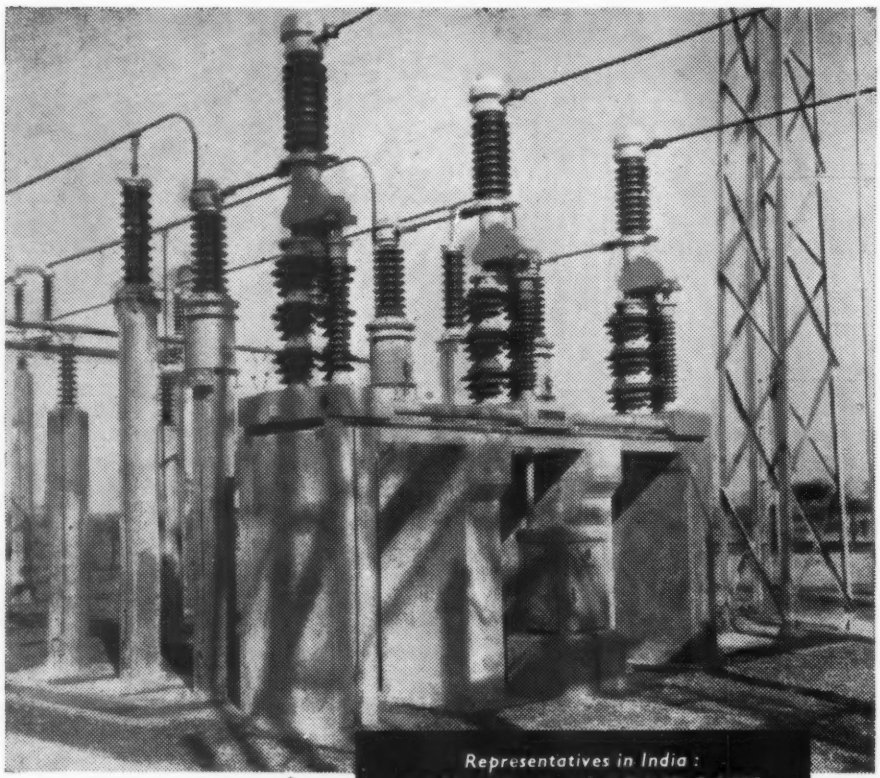
PRATAP BUILDINGS - CONNAUGHT CIRCUS - NEW DELHI

Branches : **BOMBAY - CALCUTTA - MADRAS - PATNA - KANPUR**

SWITCHGEAR UPTO 525 kV

DELLE

(Switchgear Factory of C.G.E., France)



Small Oil Volume Circuit Breaker 66 kV, 1500 MVA, with associated Current Transformers and Lightning Arresters at Broach Sub-station, Bombay State Electricity Board.

Representatives in India :

BATLIBOI & COMPANY

Proprietors :

BHOGILAL LEHERCHAND

PRIVATE LIMITED

Head Office : Forbes Ssreet, Fort, Bombay

Branches : Madras - Calcutta - Delhi - Ahmedabad - Coimbatore - Kanpur - Vijayawada

Secunderabad-Dn. Associates in Bangalore

SISTA'S-B-141

would not adversely affect irrigation and navigation, recommended modification of the basic planning of the power station as proposed in the memorandum.

According to Voorduin Plan, the power station was located on the left bank of the diversion channel. The location did not prove suitable for installation of 40 mW Kaplan turbine units which require considerable depth of excavation. On investigation, the elevation of the rock profile on the right bank of the diversion channel was found to suit such installation and accordingly the power station has been located on the right bank. The changed location of the power station, however, gave rise to complications in respect of economical layout of power station vis-a-vis switchyard, which was also planned for location on the left bank. Investigations were made to determine the most economical switchyard location, which has been finally chosen on the right side of the power station on a natural elevated ground in preference to the proposal for roof-top location or left bank location.

The location plan of the main features of the project can be seen in fig. 1.

Before finalising the design of the power plant and station, studies have been made on various design features, some of which are discussed below briefly.

(A) Output and Head of Water Turbine

The river bed downstream of the dam will degrade quickly by about 10 ft. as soon as the dam begins to operate. The degradation over years may be as much as 20 ft. Such degradation of tailrace can be utilized to increase the station capacity and energy, provided the following safeguards are taken initially.

- — the maximum gross head for which the water turbine is to be designed should be such as to cover the increase in head due to gradation. If 20 ft. degradation is to be taken care of, the maximum gross head for which the turbine is to be designed should be 124 ft. (El. 445.0 top of gates minus El. 321.0 tailwater level with undersluice discharge).
- — the draft tube should be so arranged that the top of its exit is below the tailwater level after degradation.
- — the generator, transformer and bus ducts should be adequately rated to utilize the extra turbine output.

In Panchet Hill, the final design adopted, for the purpose of specification, envisaged that the turbine should be designed for a maximum gross head of 114 ft., the capacity limited to 40 mW at the rated head of 81 ft. net and above, and that the top of draft tube exit should be at El. 305.0 or lower by adopting a rising bottom type draft tube. It has also been arranged that the generating unit will undergo an emergency shutdown including closure of the intake gates, if the gross head on the turbine exceeds 114 ft. under any combination of reservoir and tailwater levels.

Other design details included in the specification are

- — that the normal operating speed of the turbine should be 125 R.P.M. only;
- — that the turbine spiral casing should have an entrance diameter of 24 ft. only, terminating at a distance of 25 ft. from the turbine longitudinal centre-line;
- — that the centre-line distance between No. 1 and the future No. 2 unit should be 72 ft. (in any case not to exceed 75 ft.);
- — that the bottom of the draft tube should be at El. 268.0 or higher;
- — that the complete generating unit should be designed for automatic control upto the stage when it could be manually synchronised, with provision for future automatic synchronisation and load & frequency control;
- — that the thrust bearing could be located on the generator lower bracktt or turbine head cover;
- — that the generator support barrel could be of steel or reinforced concrete;
- — that acceptance test of the turbine should be conducted by testing a scale model at maker's works or by actual measurement at site.

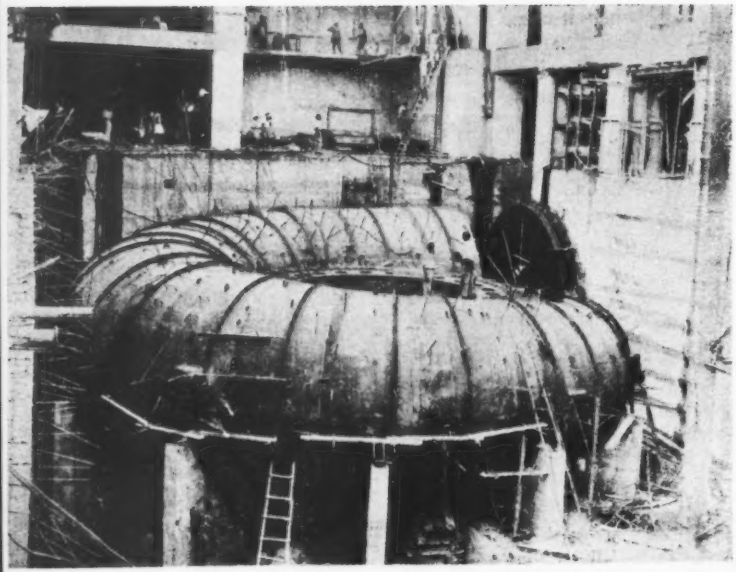
The Panchet Hill turbine as installed has fulfilled all the above-mentioned design conditions in the sense that

- — it will deliver a full load guaranteed output of 40 mW at all heads from 81 ft and above in the initial conditions and at the heads from 94 ft and above when the tailrace degrades by 10 ft in future, while operating at a speed of 125 RPM with the distributor centre-line at El. 315.0 and a spiral casing having entrance diameter of 24 ft;
- — the centre-line distance between units will be 72 ft;
- — the draft tube bottom will be at El. 268.0 and its exit will have a top elevation of El. 299.26.

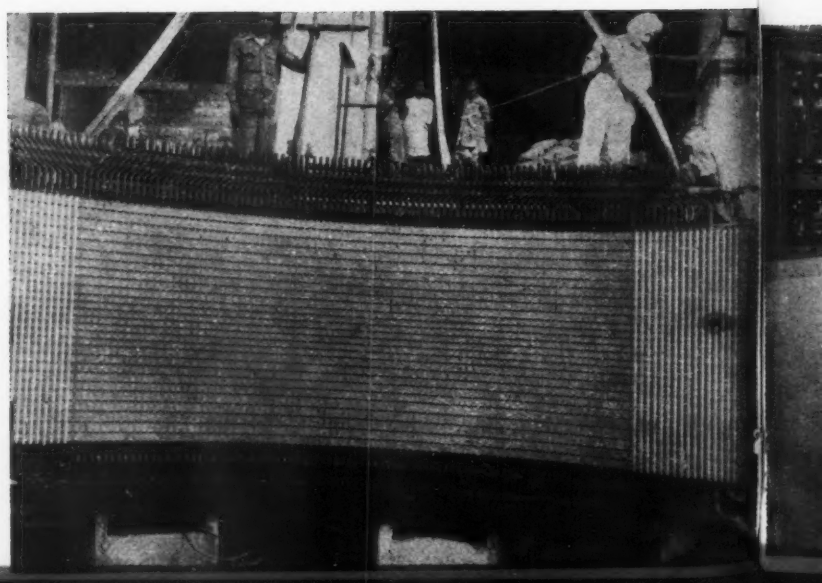
(B) Outdoor vs Indoor installation

In the original planning, the power station was designed as an outdoor installation similar to the American power stations Kentucky and Hiwassee. On detailed study it was found that such an installation with an ultimate of two units in the station would be costlier than the conventional indoor installation, apart from the disadvantages in respect of expeditions repair and maintenance. The final design is therefore based on an indoor installation, with only one floor at the turbine level and a small deck around a quadrant of the generator at its top elevation, serving as the access to the exciter and oil head

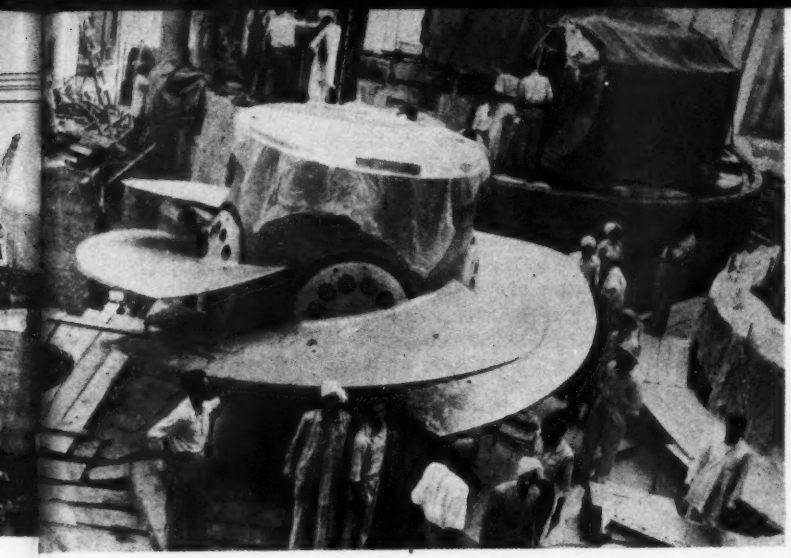
Work in progress at Panchet Power House.



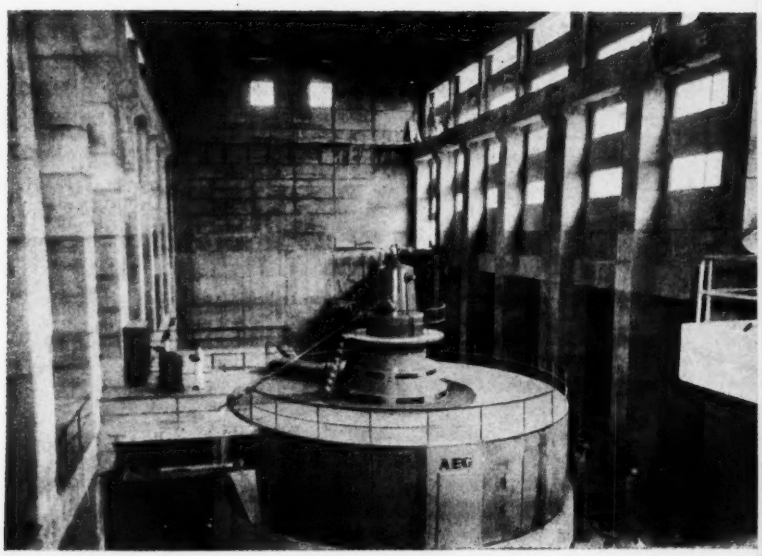
Laying of Scroll case at Panchet Hydel Station.



Assembling the Generator at Panchet Hydel Station.



Runner assembly inside power house at Panchet.



The 40 mW generator at Panchet Hydel Station.

Power House Control Panel; Panchet Hydel Station.

from the control room and as the cover over the space where the major auxiliaries of the turbine and generator are located.

(C) Concrete or Steel Spiral casing

The head conditions existing in Panchet Hill indicated that instead of a steel spiral casing to be imported from abroad, a concrete semi-spiral casing could be used. There are concrete casings in some American power stations, namely Boone, TVA (three 34500 HP Francis units under 36 to 124 ft. head), Douglas I, TVA (two 41500 HP Francis units under 47-129 ft head) and Shawinigan, Canada (ten 55000 HP Francis units under 95-115 ft head). By using concrete semi-spiral casing of rectangular cross-section with chamfered corners and depth distributed in the ratio 1:2 above and below the distributor centreline, considerable saving could be effected in the power station cost, intake cost and also in the turbine-generator cost (due to lower requirement of WR^2 for similar regulation performance.) Finally, however, a steel spiral casing has been chosen as it was apprehended that with concrete casing the construction time would be more and depending upon the quality of concreting work it might lead to difficult maintenance problems due to leakage.

The power station layout can be seen in fig. 2 (Plan) and fig. 3 (Cross-section). So far as the second generating unit is concerned, the constructional work has been so completed that the future unit only has to be purchased and installed.

The central hall of the power station at a floor elevation of El. 333.00 houses the turbine-generator units and the governing oil system. The erection bay with marked spaces for generator rotor and turbine runner erection is also on this floor adjacent to the unloading bay at El. 360.0, which serves as the entrance to the power station. The central hall, erection bay and the unloading bay are all serviced by a 225 ton electric overhead travelling crane, provided with two 112.5 ton main hooks and two 25 ton auxiliary hooks. The elevation of the crane runway rails, spaced 65 ft. apart, is El. 388.0. The roof of the central hall and unloading bay is at El. 408.0. It will be noted that the two end walls of the power station are the spillway training wall on the far side and the retaining wall on the near side.

The central hall has annexe on both downstream and upstream sides. The annexe on the downstream side at El. 333.0 floor is the roof over the draft tube and houses the 11 kV bus duct dividing cubicles, 415 volt L.T.A.C. switchboard and unwatering pit and pumpsets. The roof over this annexe with a floor level at El. 360.0 (which is the maximum possible flood water level on the downstream side), on which are mounted the main 55 mVA 11/132 kV OFW type power transformers, 750 kVA 11/0.4 kV unit auxiliary and standby transformers and the draft tube gantry crane. On the upstream side the annexe is of two-floor construction, one at El. 333.0 housing the L.T. A.C. switchboard, D.C. switchboard, battery and battery charging equipment, and the other at El. 347.67 housing the control room for the power plant as well as for the switchyard, spillway gates, undersluices, carrier equipment and air-conditioning equipment. It also houses the 415 volt L.T. A.C switchboard for the dam auxiliaries, office, record room and other attendant facilities. The entire hall with roof at El. 360.0 is to be air-conditioned (kitchen and wash rooms have been excluded from the conditioned zone).

WATER PASSAGE

The intake blocks are each 72′ long and the horizontal distance between the face of the intake and the unit centre-line is 158′-6″. The intake for each generating unit comprises two rectangular openings each 16′ wide × 30′ high and the intake gates are dimensioned 19′ wide × 30′-6″ high. There will be only one emergency service gate for both units, dimensioned suitably for placement in the slots provided on the upstream of the intake gates. The emergency service gate lowering and maintenance of the intake gates will be done by the 60 ton spillway gantry crane.

The rectangular section at the intake mouth is gradually transformed into a circular section of 28′ diameter in a concrete transition length of 63′6″. From this point, the steel lined penstock of 28′ diameter continues for a length of 35′-0″ and the penstock hereafter is a steel lined taper piece from 28′ diameter to 24′ diameter over a length of about 35′-0″ when it meets the entrace of the steel spiral casing.

The dimensions of the water passage have been chosen on economic and other considerations, commensurate with satisfactory speed and pressure regulation of the turbine on sudden change of load. Studies were made on the comparative analysis of double intake and single intake, but ultimately the double intake has been preferred because this would ensure greater structural strength of the intake blocks and easier maintenance and handling of service and emergency gates of smaller weights.

MAIN PLANT

Fig. 4 shows the main One Line Diagram of the main plant and the switchyard. A description of the main plant is given in the following:

(A) Turbine

The turbine is of the vertical shaft Kaplan type, designed for delivering 56000 HP under the rated net head of 81 ft. and capable of working satisfactorily over the head range of 66 ft to 113 ft. with the present and future tailrace conditions. The technical data is given in Table I.

TABLE I

Net head, ft. (present)	103	81	66
Tailwater, El	341	325	325
Cavitation limit output, HP	78000	60000	46000

Guaranteed full load output, HP		56000		56000	42000
Guaranteed weighted efficiency (mean of efficiencies at 100, 90, 80, 70, 60 and 50% guaranteed full load output) percent.				91.23	
Net head, ft. (Future)		113		94	76
Tailwater, El.	331		315	315	315
Caviation limit output, HP	80000		62400	56000	48500
Guaranteed full load output, HP	56000		56000	56000	48000
Normal speed, RPM				125	
Max. runaway speed, RPM				370	
Max. hydraulic thrust, Ton				800	
Runner diameter, inch				212.6	
No. of blades, material				5, stainless steel (13 Cr.)	
Range of blade movement, degrees				30	
Total weight of runner without oil, tons				89	
Turbine shaft dia. inch				35.5 (13.5 bore)	
Turbine shaft weight, tons				30	
Distributor centre-line, El.				315.00	
No. of stay vanes				22 + 1 baffle	
No of wicket gates				24	
Wicket gate servomotor capacity, ft. lb.				470,000	
Blade servomotor capacity, ft. lb				1085,000	

The turbine runner has 5 adjustable blades which are connected by means of levers and links to a crosshead made in one piece with the piston rod, which is in turn connected to the blade servomotor piston. The runner servomotor cylinder is located above the runner blades and cast integral with the runner hub. The runner hub is always filled with oil, which is ensured by connecting the runner hub to the outlet channel for the oil to the blade servomotor. Blades are provided with seals to prevent oil leaking out and water penetrating into.

The runner is provided with runaway speed limiting device, which at a certain increase in speed automatically brings the runner blades to their maximum opening whereby the runaway speed does not appreciably exceed twice the normal speed even with fully open distributor.

The wicket gate servomotors, 2 in number, are placed on the turbine head cover and the servomotor pistons are directly connected to the gate operating ring by means of links and bolts. The wicket gates can be automatically locked in the closed position and manually locked in the open position. A leakage oil sump tank provided with oil pump and located in the turbine pit serves as a collector of the servomotor leakage oil or drainage oil for putting the same back into the main oil sump tank.

The turbine is provided with:

— a guide bearing, which is white-metal lined and self-lubricating in oil. (It is provided with an oil reservoir equipped with a standby oil pump, thermometers and thermostat relay. The relay is set for alarm at 65°C. and shutdown at 70°C. The oil cooler of seamless coils of corrosion-resistant material, is embedded in the bearing shell);

— a stuffing box, into which high pressure water is injected from top (High pressure water is obtained by two small booster pumps with suction connected with raw water line) for cleaning and scavenging purposes;

— two motor-driven pumpsets for disposal of leakage water from below the head cover, controlled by a level governor.

The space required by the turbine with its stay ring and accessories is 31′-4¾″ from shaft coupling to runner cone over a diameter of 25′-0″, which shows the compactness of the accessories.

The assembled spiral casing and all parts subjected to full water pressure have been designed for a hydrostatic pressure of 100 p.s.i.

(B) Electro-hydraulic Governor with Electronic Regulator and Governor Oil System

The governor provided with the turbine for controlling its speed is of the electro-hydraulic type with an electronic regulator. The speed-sensitive element of the governor head is an electronic amplification circuit with two electronic valves connected in push-pull, two anode transformers, a L-C frequency sensitive circuit with an external capacitance and a damping circuit. The element receives the power supply and control impulses from the permanent magnet generator driven from the turbine shaft. The control mechanism of the governor head comprises a coil, a spring and an oil pressure operated regulating valve. The weak impulses generating in this coil on a variation of speed are increased to about 100 kg.

The governor is provided with gate limit device, speed adjustment device, speed droop adjustor and automatic shutdown devices, all mounted on a cabinet located on the deck hugging the top of the generator and the electronic apparatus are mounted in a separate control panel, also located close to the governor cabinet.

The oil pressure system comprises a 5220 gallon sump tank located close to the turbine having its top at El. 333.0, a 3460 gallon pressure tank mounted on the sump tank, two oil pumps each driven by 98 HP 1460 RPM motor with necessary unloader valve,

safety valve etc. The sump tank is provided with an oil cooler and oil cleaning filter.

The special advantage of the type of governing system used will be derived if identical governing system is used with the proposed second generating unit, in which event both the generating units can be set for joint operation, meaning that the entire station is operated as if it consists of only one single unit, both units sharing the load in the most favourable proportion depending on the turbine gate settings.

(C) Synchronous Generator

The synchronous generator rated 47060 kVA at 0.85 lagging power factor 11 kV $\pm$10%, 3 phase, 125 RPM is of vertical shaft umbrella construction. The combined guide and thrust bearing is supported on the bottom bracket and the main and pilot exciters and oil head are supported on the upper bracket. The technical data of the generator is given in Table II.

TABLE II

Output at .85 lagging power factor, kVA	47.060
Guaranteed efficiency at 100% load, %	97.52
75% load, %	97.27
50% load, %	96.54
Short circuit ratio	1.2
Reactances %	
Direct Axis synchronous	95
Direct Axis transient saturated	28
Direct Axis subtransient saturated	19
Negative sequence	24.5
Zero sequence	7
WR^2, lb-ft.^{2}	43.8×10^6
Line charging capacity, kVA	35000
Stator	
Outside dia. of core, inch	300
Inside dia. of core, inch	277
Length of active iron, inch	64.5
Weight of active iron, lbs.	124,000
Weight of copper, lbs	19,800
Width of air gap, inch	0.51
Flux density in air gap, lines/cm^2	7870
Flux density in teeth, lines/cm^2	16200
Weight of complete stator, tons	110
Rotor weight, tons	215
Generator housing	
Height, inch	108.5
Diameter, inch	414
Generator shaft	
Diameter inch	33.46 (13.58 bore)
Weight, tons	43
Main exciter rating, KW	250
Pilot exciter rating, KW	20
Main exciter voltage, volts	250
Pilot exciter voltage, volts	230
Insulation	Class B through out

The generator is provided with 8 air coolers, brakes and jacks and a GFA-4 type automatic voltage regulator of I.G.E. make.

(D) 11 kV Bus Ducts

The 11 kV metal clad bus ducts from the generator to the 55 mVA power transformer are of double channel copper, each 100 mm $\times$ 10 mm. The buses are spaced 1'-3" apart with 10" clearance from sides, and are designed for a continuous current rating of 3000 amps with the temperature rise of conductors limited to 20°C above an ambient of 50°C in still but unconfined air. A small blower has also been provided to ensure better performance and longer life. The portion of the bus ducts from the generator to the cubicle is laid on a trench on the central hall floor at El. 333.0 and the other portion of bus ducts is anchored to the underside of El. 360.0 roof of the downstream annexe.

11 kV cubicle, measuring 15'-1.1/8" long $\times$ 4'11.1/6" deep $\times$ 9'-10.1/8" high, is divided in three compartments, the central compartment being arranged to receive the bus ducts from below and lead out the bus ducts from above. The equipments provided in the cubicle are:

Central compartment:—3 sets of 3000/5 Amp CTS, one set with 15 VA burden for differential protection, one set with 60 VA burden for metering and the other set with 50 VA burden for voltage regulator; 1 set of 3000 Amp rating isolating switch, pneumatically operated.

Left side compartment:—2 sets of 11000/110 volts PTS of 90 VA burden (fuse protected), one set for metering and the other for voltage regulator; 1 set of 600 Amp rating manually operated isolating switch; surge protection equipment comprising lightning arrestors and capacitors.

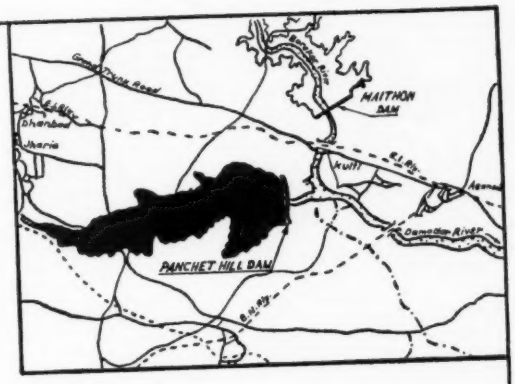
Right side compartment:—1 set of 600 Amp rating pneumatically operated disconnecting switch; 2 sets of 250/5 Amp CTS, one set with 30 VA for metering & overcurrent protection and the other set with 15 VA for overall generator-transformer differntial protection; provision for connection of the bus ducts in the cubicle to 11 kV cable to the 750 kVA 11/.4 kV unit auxiliary transformer.

(D) Power Transformer

The power transformer for the generating unit is rated 55000 kVA 11/132 kV delta-star and is of the OFW type. The primary winding is insulated throughout for 15 kV class insulation and the secondary winding is for 138 kV class. There are two 6 HP 400 V 3 phase 50 cycles A.C. motor driven oil pumps for the transformer, one standby to the other. The transformer is also provided with two 100% duty coolers, receiving the water from the station raw water mains. The off-load tap changing gear provided on the h.v. side of the transfomer allows voltage variation of +7.5%, $\pm$5%, and $\pm$2.5%.

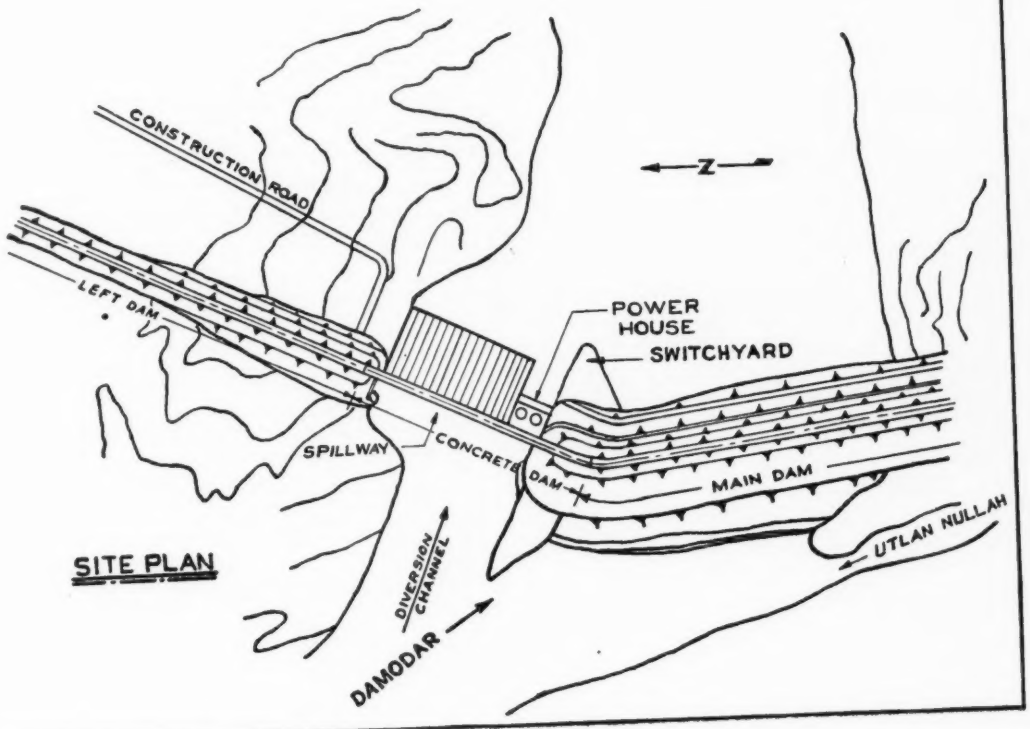
Due to the large weight of the assembled transformer, not being transportable over the roadway linking Panchet Hill site to the nearest railhead, the

FIG. 1



LOCALITY MAP

SCALE 4 0 4 8 12 MILES



SITE PLAN

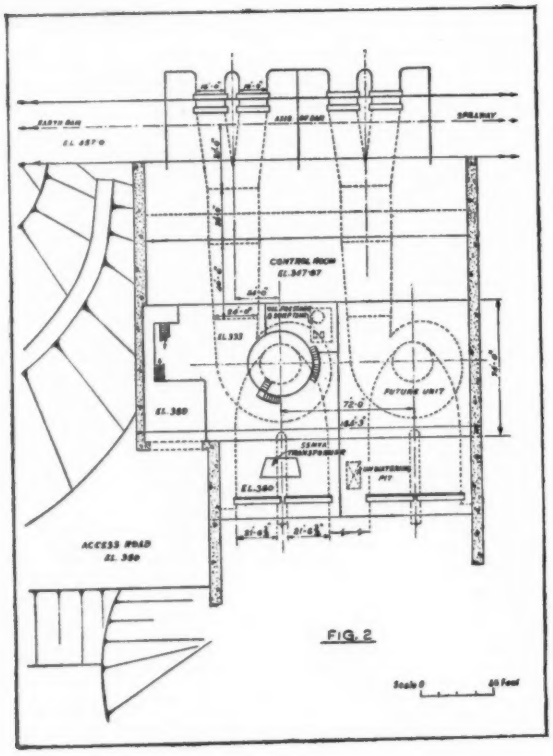
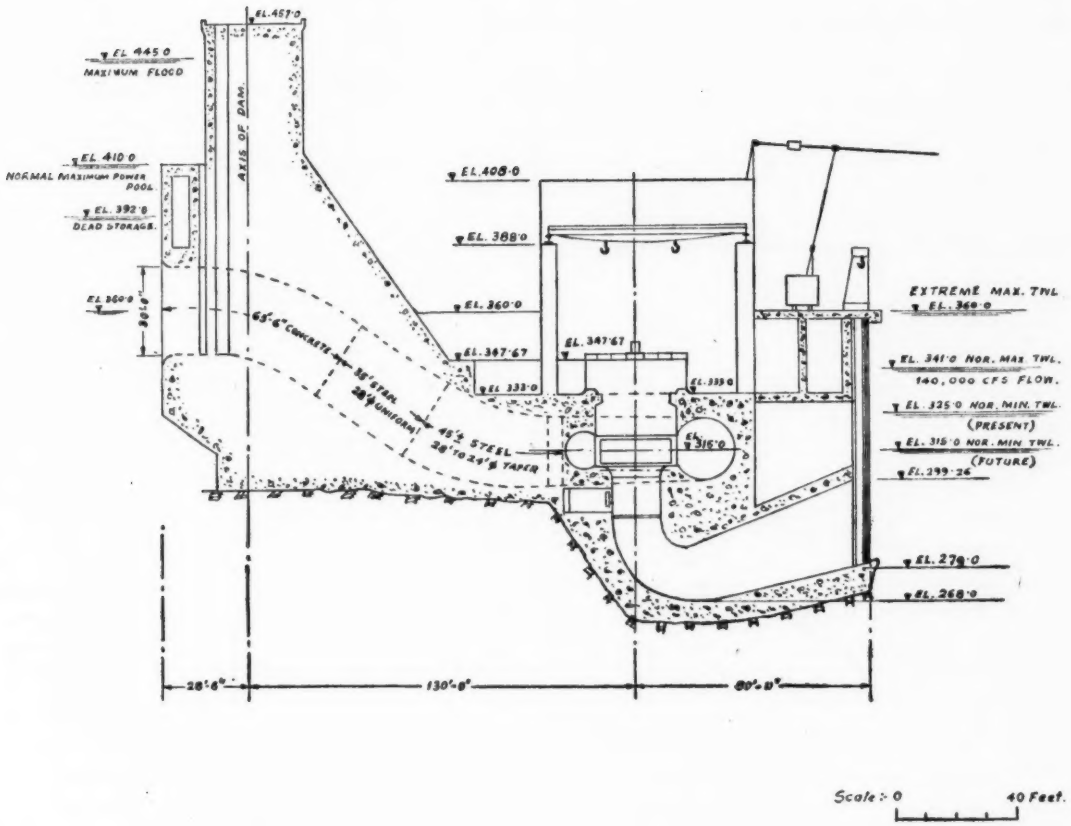
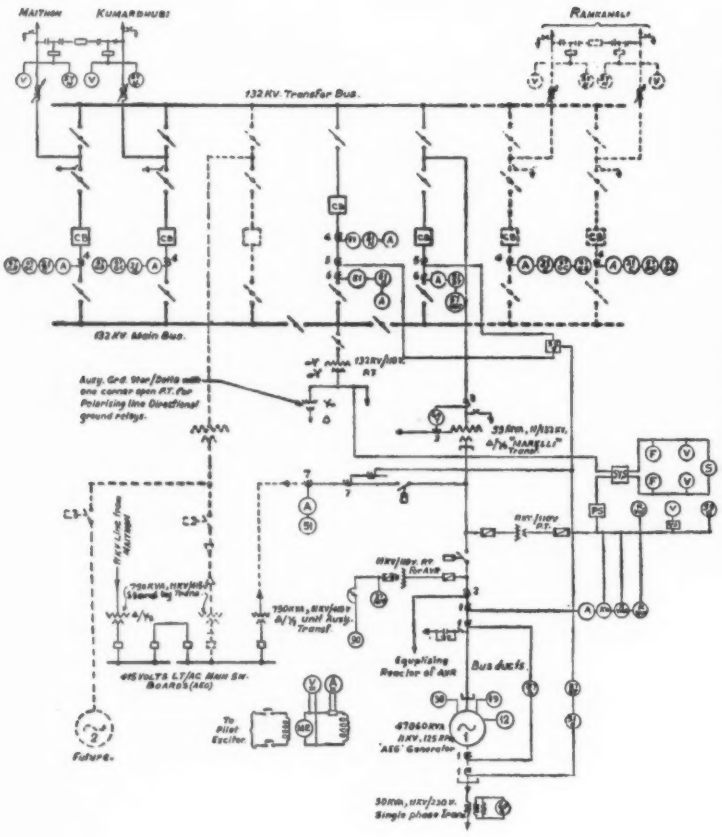

EARTH DAM
EL. 457'0
SPILLWAY
CONTROL ROOM
EL. 347'87
EL. 333
EL. 360
FUTURE UNIT
EL. 340
ACCESS ROAD
EL. 350
Scale 0
40 Feet

FIG. 2

FIG. 3


EL. 467·0
EL. 445·0
MAXIMUM FLOOD
EL. 410·0
NORMAL MAXIMUM POWER POOL
EL. 392·0
DEAD STORAGE
AXIS OF DAM
EL. 360·0
65'-6" CONCRETE
36" STEEL
28% UNIFORM
45½ STEEL
36" TO 24" 8% TAPER
EL. 408·0
EL. 388·0
EL. 360·0
EL. 347·67
EL. 367·67
EL. 333·0
EL. 333·0
EL. 316·0
EXTREME MAX. TWL
EL. 360·0
EL. 341·0 NOR. MAX. TWL.
140,000 CFS FLOW.
EL. 325·0 NOR. MIN. TWL.
(PRESENT)
EL. 315·0 NOR. MIN. TWL.
(FUTURE)
EL. 299·26
EL. 279·0
EL. 268·0
28'-6"
130'-0"
80'-0"
Scale :- 0
40 Feet.


MAITHON
KUMARDHUBI
RAMKANALI
132 KV. Transfer Bus.
132 KV. Main Bus.
Auxy. Grd. Star/Delta with one corner open P.T. for Polarising line Directional ground relays.
132 KV/110 V. P.T.
33 KVA., 11 KV/231 V. A/N "HARELL" Transf.
11 KV/110 V. P.T.
11 KV/Line P.T.
11 KV Line from Adityapur
750 KVA., 11 KV/433 V. Stand by Trans.
750 KVA., 11 KV/433 V. A/N Unit Auxy. Transf.
415 VOLTS L.T./A.C. Main Sw. BOARDS (ACB)
Future.
To Pilot Exciter.
47500 KVA. 11 KV., 125 RPM. 'A.G.' Generator
Equalising Reactor of AVR
Bus ducts.
50 KVA., 11 KV/230 V. Single phase Trans.

LEGEND

INDICATING INSTRUMENT

- (A) — A.C. Ammeter.
- (A) — D.C. Ammeter.
- (V) — A.C. Voltmeter.
- (V) — D.C. Voltmeter.
- (W) — Kilo Wattmeter.
- (VA) — Kilo Var meter.
- (WH) — Kilo Watt hour meter.
- (F) — Frequency meter.
- (S) — Synchroscope.

RECORDING INSTRUMENT

- (W/F) — Combined Recorder for voltage & frequency.

SWITCHES

- (S) — Synchronising switch.
- (VS) — Voltmeter selector switch.
- (AS) — Differential C.T. selector switch.

DEVICES

- 12 — Overspeed
- 38 — Bearing thermal.
- 49 — Temperature.
- 50 — B.V.B. master element.
- — Wave trap
- CB — 132 KV. Power circuit breaker
- PS — Phase shifting device with taps.
- — Lightning arrester.
- — Bus ducts.

RELAYS

- 51 — Overcurrent
- 51N — Ground overcurrent.
- 87G — Generator differential
- 87T — Transformer differential
- 64G — Generator stator ground fault.
- 64T — Transf. restricted earth fault.
- 59G — Generator overvoltage
- 64F — Generator rotor ground fault
- 27-AVR — Undervoltage in AVR circuit.
- 21G — Directional distance relay with carrier
- 67GC — Carrier ground directional overcurrent
- 67GB — Back-up ground directional overcurrent.

C.T. RATIO

- 1 — 3000/5 (3 nos)
- 2 — 3000/5 (1 no)
- 3 — 300/5
- 4 — 600 - 300 - 150/5
- 5 — 300/5
- 6 — 300 - 150/5
- 7 — 250/5

FIGURE-4

transformer was brought in parts, each winding column separately and the core and tank in one assembly, for ultimate assembly at site. Untanking of the transformer will be done by bringing the transformer inside the power station.

(E) Control, Protection and Metering System

The generating unit is arranged for being controlled automatically from the control room. The control circuits have been so designed that the generating unit can be started and stopped by means of 'master start' and 'stop' pushbuttons mounted on the panel. Interlock contacts have been provided in each control circuit such that there could be no maloperation.

Operation of the 'master start' pushbutton will energise the master starting relay and a starting auxiliary relay, whose contacts will close to

(i) open the intake gates

(ii) start up the governor oil pump

(iii) start up the oil vapour exhaust fan in the oil head

(iv) open the motor-operated raw water valve

(v) start up the booster pumps for injecting high pressure water into the stuffing box

(vi) start up the transformer oil pump motor

(vii) energise the auxiliary D.C. busses to render the fault contacts operative

(viii) energise the first stage completion relay after all the above are complete, permitting the release of the wicket gate lock, opening of the wicket gates and spinning of the unit.

When 50% speed is reached a relay will be energised to permit the runner blades to come into synchronism with the opening of the wicket gates. When the speed reaches to 80%, a relay will operate to bring the electronic regulator into action. At 90% speed, another relay will pick up enabling, through an auxiliary relay, energisation of the transfer relay which indicates that the unit is now on full rated speed and can be synchronized with the grid.

Normal shutdown is effected by pressing the 'stop' pushbutton, which will do the following functions

— energise stop relay

— bring the gate limiter to zero position

— permit closure of intake gates and application of the generator brakes at 50% speed

— energise auxiliary stop relay, permitting shutdown of all auxiliaries like governor oil pump, booster pump etc.

An excess time relay has also been provided, which will trip the master start relay and energise the normal stop relay bringing the unit at standstill condition, if the unit in its starting sequence fails to reach its final stage within a predetermined time.

The emergency shutdown of the generating unit is effected automatically on the operation of the protective relays associated with the generating unit. Three shutdown relays have been used to classify the various major faults into three categories, each having its own special feature on the extent and fastness of the shutdown as discussed below:

Relay No. 1—This relay is energised on the occurrence of major electrical faults which are likely to cause damage to the machine. This relay will trip the 132 kV breaker, generator field breaker and operate the governor shutdown solenoid to bring the unit to standstill.

Relay No. 2—This relay is energised on the occurrence of major mechanical faults which require the machine to be brought to standstill in the quickest possible time. This relay will operate on the governor solenoid and will trip the 132 kV breaker when the unit has reached speed-no-load condition and the generator field breaker when the machine has come to rest. By doing this selective tripping, sudden load rejection is avoided and full braking effect due to generator field has been derived to quicken the shutdown.

Relay No. 3—This relay is energised on the occurrence of major electrical faults which are considered non-damaging in nature. The circuits are so arranged that while the 132 kV breaker and the generator field breaker will be instantaneously disconnected, the generating unit will continue to run at speed-no-load, ready for switching in as soon as the fault is checked and cleared.

The control circuits for closure of the intake gates have been so designed that the gates will independently close on the occurrence of major faults.

The emergency shutdown relays can also be energised manually through pushbuttons, located on the control panel and also near the generating unit.

For convenience, the controls are located on a desk control board in front of the upright panels. The desk control board houses all control pushbuttons, indicating lamps, alarm/annunciation facia, instruments, mimic diagram and the upright panels house all relays, instruments etc. The generating unit has also the following panels—turbine gauge panel, electronic regulator, actuator cabinet and de-excitation cubicle. The terminal blocks in each of these panels have been so laid that the cores of the interconnecting cables will enter into successive terminals in the block, thereby enabling neat interconnection wiring without having different lengths of tails.

ACCESSORIES

(A) Auxiliary L.T AC and DC supply

As indicated in the Main One line Diagram, auxiliary 415 volts 3 phase and 240 volts 1 phase AC power are derived from the unit auxiliary transformer. A standby source has been provided by way

of the 11 kV transmission line from Maithon to Panchet Hill laid during construction stages and a 750 kVA 11/0.415 kV power transformer at Panchet Hill end. The layout of the LT AC Boards, one on the upstream side to which the unit auxiliary transformer is connected and the other on the downstream side to which the standby transformer is connected with tie breakers connecting the two boards is such as to reduce the requirement of power cables to the minimum. The upstream board feeds the Dam Auxiliary switchboard and turbine pit distribution switchboard. The control of the incoming breakers and the tie breakers for the two main AC Boards is provided on the Desk Control Board in the control room.

The D.C. System of 250 volts is derived from a bank of lead-acid cells, provided with two 100% duty selenium rectifier for slow and quick charging.

(B) Unwatering and Sump pumps

For unwatering of the water passage, two unwatering pumps suitable for closed system pumping have been provided each driven by a 60 HP motor. Unwatering operation has been limited to the extent that no operation can be undertaken when the tailwater level is El. 341.0 or above, which will last for a short period during floods in the monsoon. This has been done to ensure minimum cost of pumpset commensurate with reasonable protection against idle time which the unit has to pass through during monsoon if unwatering is required.

The sump pump also driven by a 50 HP motor will pump water from the unwatering pit where all drainage and seepage water will collect.

All the pumps are of vertical shaft design with about 60 ft long spindles and of the submerged type. The pit also houses a set of valves arranged in such a way that, if required, the unwatering pumps can be brought in to assist the sump pump. The sump pump is float-controlled while the unwatering pumps are manually controlled.

(C) Level Gauges, Gross Head Recorder and Flowmeter

The station is provided with two level gauges one for the reservoir and the other for the tailrace to indicate and record the respective levels. The level gauges are selsyn motor operated. The selsyn circuits have been so connected that the differential between the two levels will actuate the gross head indicating and recording unit. The indicating-cum-recording instruments for the level gauges and for gross head have been mounted on the spillway gate control panel in the power station control room.

The turbine is also provided with an indicating-cum-integrating-cum-recording flowmeter.

(D) Other facilities

Other facilities like treated water system, compressed air system, fire protection, ventilation, sanitary system etc., have been provided in the power station. These are of conventional nature. Almost all cables in the power station have been laid on trays in multiple tier in most places and in single tier in others, carried below the floor slabs, in order to ensure neatness of the power station.

LIST OF CONTRACTORS FOR MAJOR EQUIPMENTS

The major equipments for the power station and switchyard have been manufactured by the following firms. All erection work has been done departmentally, with supervisory erection engineering personnel from the suppliers of Turbine, Generator and Transformer.

Turbine & Governor	... Nydqvist & Holm Aktiebolag Trollhattan, Sweden
Crane	... Titovi Zavodi Litostroj Ljubljana, Yugoslavia
Level Gauges	... Leupold & Stevens, U.S.A.
Flowmeter	... Evershed & Vignoles, U.K.
Unwatering pumps	... Sulzer and Brown Boveri, Switzerland
Generator	... Allgemiene Elektricitas Gesselschaft, Berlin, W. Germany
Main Transformer	... Ercole Marelli, Milano, Italy
11 kV Busducts & Cubicle, LT. AC & DC switchboards	... Allegemiene Elektricitas Gesselschaft, Frankfurt, West Germany
Control Panels	... ASEA, Sweden
Distance Relays	... I.G.E., U.S.A.
Power & Control Cables	... Siemens Schuckert Werke West Germany Edison Swan, U.K. Mersey Cables, U.K. Aberdare Cables, U.K.
132 kV Circuit Breakers	... Magrini, Italy
132 kV Disconnects	... Alpha, Nidau, Switzerland
132 kV P.T.	... ASEA, Sweden

TOWER AT HOME

AND

MACHINERIES FROM ABROAD

PIONEERS OF TRASMISSION LINE TOWERS—ABOUT 1200 MILES OF ERECTION OF TRANSMISSION TOWERS—DESIGNING 100 SUBSTATION STRUCTURES AND 30 COMMUNICATION AND AERIAL MASTS

KAMANIS ARE ALSO ENGAGED IN THE IMPORT OF MACHINERIES LIGHT AND HEAVY NOT MANUFACTURED IN INDIA FROM WORLD RENOWNED FOREIGN FIRMS

TRANSMISSION LINE TOWERS

HYDRO ELECTRIC EQUIPMENT—TURBINES, GENERATORS AND TRANSFORMERS ★ LOW OIL VOLUME CIRCUIT BREAKERS ★ PNEUMATICAL SWITCHES ★ BULK OIL SWITCHES ★ KNIFE SWITCHES ★ BUSHING INSULATORS ★ VOLTAGE AND CURRENT TRANSFORMERS ★ FRAMES, SWITCHBOARD AND CONTROL PANELS

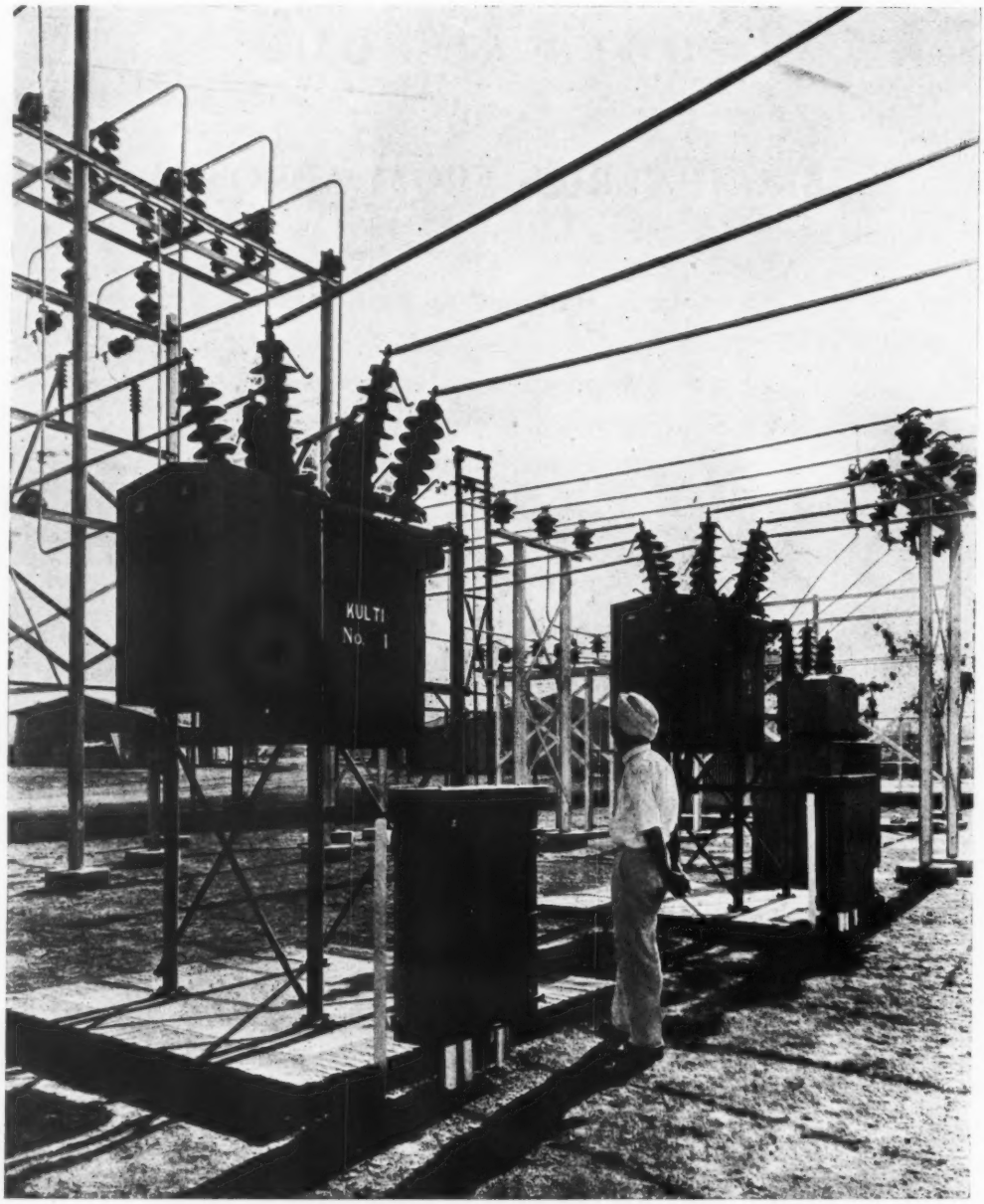
Air Blast Circuit Breakers (15 to 80 kV)
Bulk Oil Circuit Breakers (15 to 80 kV)

RAILWAY WEIGH BRIDGES ★ MOTOR TRUCK SCALES AND OTHER RECORDING & WEIGHING MACHINES

Kamani Engineering Corporation Ltd.

KAMANI CHAMBERS,
NICOL ROAD, BOMBAY

REYROLLE SWITCHGEAR



REYROLLE TYPE "ORT2" 33000 VOLT SWITCHGEAR AT MAITHON SUB/STN.
AS SUPPLIED TO D.V.C. & OTHER USERS IN INDIA, IN LARGE QUANTITIES

AGENTS:

BURN & CO., LTD.

CALCUTTA BOMBAY NEW DELHI KANPUR

BOMBAY CO. (PTE.) LTD.

MADRAS & SOUTHERN INDIA

Shortage of Power in Damodar Valley and Operation of the DVC System

B. N. BANERJEE

THE 40 mW unit of Panchet Hill Hydro-electric Power Station has come into operation and is now connected to the extensive 132 kV network of the DVC Power System as shown in fig. 1. This precious relief to the overstrained Power System is to be regarded as a seasonal one since it depends on the water energy left over for power generation purposes after meeting the irrigation and flood control requirements. Fortunately, the additional thermal plants of the DVC are scheduled to come into operation in succession from the first quarter of the year 1960. It has been possible now to schedule outages of all the six boilers at the Bokaro Thermal Power Station for thorough overall and inspection one after another.

The history of power development even in the industrially advanced countries has not always been smooth and free from reverses, consequently the power development at times lagged behind the system demand; the case of the DVC Power System has not proved to be an exception. Statistics of load development in various countries indicate that under normal conditions the demand usually doubles in a course of five to seven years, but the growth of load in the DVC Power System has been phenomenal. Here, the demand has actually gone up about ten times in course of only five years from 1954 to 1959 as shown in fig. 2. Initially, this development has been a bit gradual which promptly invited rather too early criticisms from many quarters expressing doubts about the utilisation of the installed capacity at Bokaro (3×50 mW each) and Tilaiya (2×2 mW each) Power Stations. This apprehension later proved to be not only incorrect but soon it was also established that the total installed capacity even after commissioning of the Maithon Hydel Station (ultimate capacity 3×20 mW each) was inadequate to safely meet the rapidly growing need of the area catered by the DVC. Power development programme in such an industrial area unless pursued continuously, lags behind the actual requirement. As stated earlier, it happened also in developed countries. Various factors may bring about this situation viz. technical, financial and even political. Many a country in the West suffered the crisis of power shortage in the immediate post-war years as development of power industry became practically nil during the war years when preference was given to the war industry. The result was power cut to non-essential consumers including domestic users and staggering of working hours and, in some cases, even weekly offs until the power industry developed to meet the normal requirement. Inspite of adequate planning by the DVC, its Power System on the face of acute shortage of foreign exchange, has been subjected to extreme difficulty due to lack of sufficient number of power plants. The ever-growing need of the industry and other consumers can hardly be met with accepted degree of security.

It is a normal practice for a Power System to keep adequate 'hot' and 'cold' reserve. This is required more in a System which is predominantly thermal since scheduled and forced outages are more frequent in a thermal power plant than in a hydel plant. The 'availability factor' of a modern water tube boiler has been considerably improved with the advancement of design, yet in consideration to the usual operation and maintenance problem associated with the utilisation of high ash coal leading to erosion problems, the expected 'availability factor' would hardly exceed 85%. The expected 'availability factor' of a modern steam turbine on the other hand is about 8 to 10% higher than the above boiler 'availability factor' and hence, the problem of meeting the system demand arises mostly due to outages of boiler and its associated plant, although occasional trouble to outages of the electrical equipment or the transmission and distribution system cannot be overruled altogether. Deferring of annual overhaul of boiler and its inspection date more than a year certainly helps to improve the 'availability' of a boiler plant and brings it closer to the turbine 'availability'; but this extension of overhauling date of a boiler plant burning high ash coal should be taken with caution as an exceptional case under emergency condition until sufficient statistics have been collected in its favour and the authority concerned approves of such mode of operation under normal condition. The steam turbine also requires inspection and overhauling after about 8,000 to 10,000 hours under normal condition, although there have been instances of continuous operation of a steam turbo alternator unit for five years or even more under unusual condition.

The above clearly establishes the absolute necessity of having reserve capacity in a Power System. A System having ample reserve capacity usually keeps a part of it as 'hot' reserve and the rest as 'cold' reserve. The 'hot' reserve has its advantages viz., its quick availability to the System as and when necessary and less boiler feed water conditioning and associated corrosion problems. The 'cold' reserve

comes to rescue when a complete unit faces scheduled or forced outage and that also for a longer period. In a predominantly thermal power system like that of the DVC, the reserve hydel capacity during the 'dry' period is kept 'cold' when the water conservation has to be given the primary consideration. Since the starting up period is considerably less for hydel unit and its operation does not call for very special attention, this reserve installed capacity when available, could be utilised, if necessary, only for peaking purposes. This mode of operation does not, however, apply during the monsoon months of the 'wet' period when maximum secondary energy available at the hydel power stations has also to be fully utilised. The major overhaul of the hydel set does not present serious problem since it could be easily carried out in rotation during the 'dry' period.

In a large interconnected Power System, advantage is often taken of the reserve in other System, but limitations are imposed in this direction by the cost involved in the transmission system and the transmission losses.

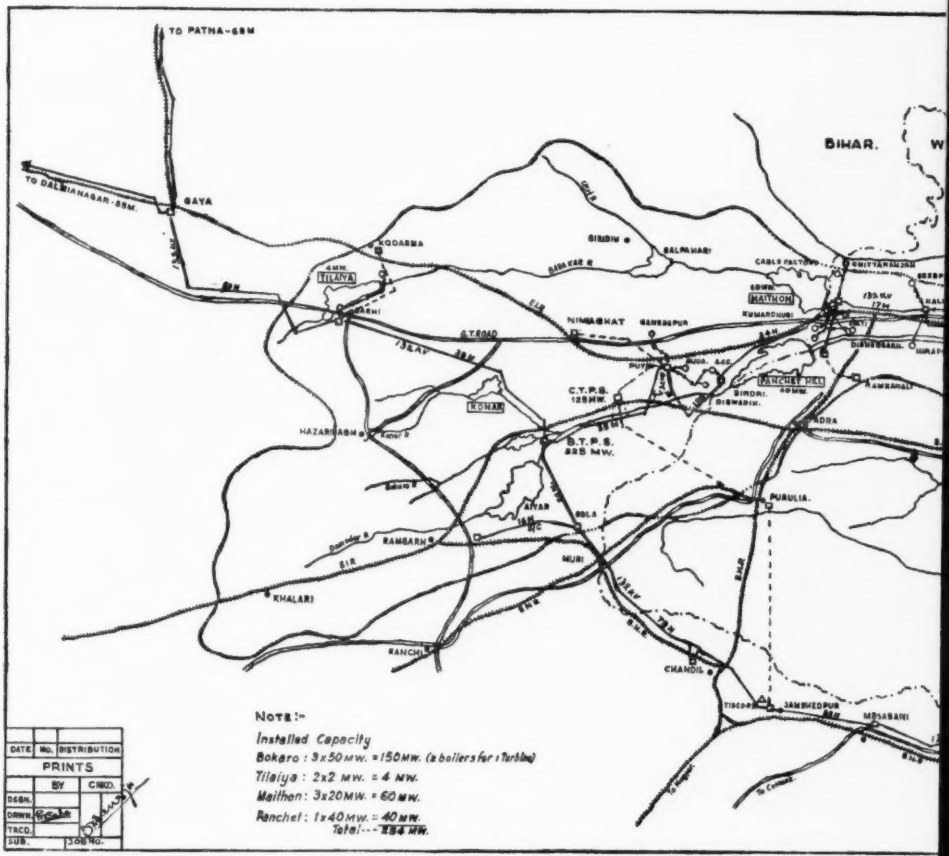
From the middle of 1957, the DVC Power System has been gradually experiencing difficulty, when the available installed capacity started to meet the system demand without spinning reserve. The usually accepted mode of safe operation by providing adequate 'hot' and 'cold' reserve under the then prevailing circumstances, had to be ruled out. This will continue inspite of some seasonal relief offered by the Panchet Hydel Station until the new thermal plants at Bokaro (1 unit at the rate of 75 mW) and Durgapore (2 units at the rate of 75 mW each) come into operation in early 1960. The West Bengal Government's power station at its coke oven plant, Durgapore having an installed capacity of 2×30 mW is also expected to come into operation shortly and help the DVC with about 30 mW suplus power initially, but the position will again deteriorate around 1961 until the sanctioned generating set at Chandrapura (1 unit of 125 mW) and the others as shown in Fig. 3 come into operation. Rihand Power System is expected to provide the DVC with about 40 mW to meet the additional traction load of the Railways until the first set at Chandrapura comes into operation. The load survey showing the potential system demand in the DVC area as has been indicated in Fig. 3 was carried out by the CW & PC in collaboration with the DVC. The overall figures of load forecast are given below along with the available capacity in the corresponding years:—

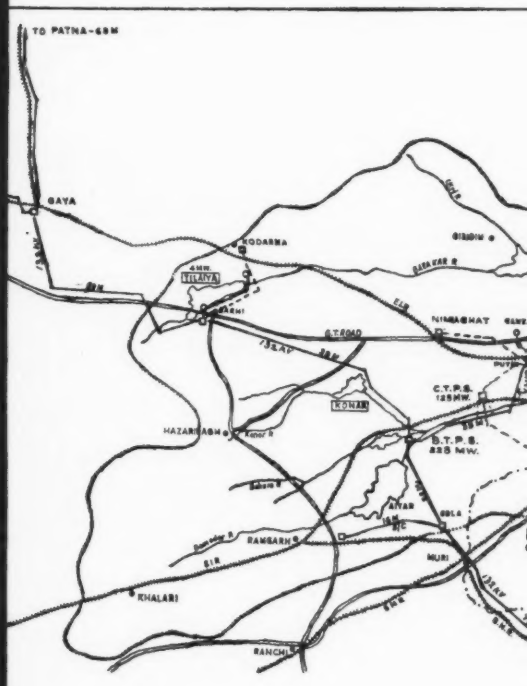
	59-60	60-61	61-62	62-63	63-64	64-65	65-66
Anticipated Demand (mW.)	396	584	693	742	829	929	1195
Firm Capacity (mW.)	209	406	477	477	477	477	477

NOTE:—60 mW. capacity of West Bengal Government's coke-oven-power station at Durgapur, has been included in the firm capacity and likewise the load expected to be served by this station has also been included in the anticipated demand as the loads fall within the area of the DVC.

At present until Panchet came into operation, of the total installed capacity of 214 mW in the DVC Power System, 150 mW is made of thermal power and the rest, hydel. To this, has now been added 40 mW hydel power from the Panchet Hill Power Station. But, the firm capacity of the hydel power is much less due to non-availability of sufficient quantity of water to generate power throughout the year. This consequently puts the strain on the only thermal station now in operation at Bokaro during the 'dry' period. The 'wet' period being limited to 4 to 5 months, it naturally became difficult to carry out the annual overhaul and inspection of all the six boilers at Bokaro during this period. This difficulty would be felt more and more as the installed capacity increases further with the commissioning of additional thermal plants in the DVC Power System at Durgapur, Bokaro and Chandrapura. The natural outcome of such development would be to cater suitable 'hot and 'cold' reserve at the Thermal Power Stations, over and above the marginal relief available from the hydel stations during the 'wet' period. The present firm capacity of the Power System according to accepted standard excluding Panchet Hydel Station, with the largest unit out for overhaul, is only 148 mW, whereas the instantaneous system peak already reached has been over 230 mW, as against the expected potential demand of 396 mW on the DVC Power System during 1959-60. After commissioning of the Panchet Hydel Station the instantaneous system peak so far reached has been over 232 mW. The maximum sustained peak for half hour so far recorded has been more than 225 mW. This will glaringly indicate the extreme shortage of generating capacity and the unusual strain suffered by the present DVC Power System owing to continuous operation of all three thermal units at Bokaro, and that too often under overload conditions with increased pressure of hydrogen used for generator cooling.

Comparative study of the typical system load curves obtained in May 1957, January 1958, September 1958, June and August 1959 as shown in the Figs. 4, 5, 6, 7 and 8 will indicate how the consumers' bare needs were met with the commissioning of hydel units at Maithon, by staggering some of their demands during non-peak hours and by all six boilers operation at Bokaro. The crests in the load curves also gradually smoothened out and the load factor of the entire system became as high as 85.4% in 1959 compared with 82% in 1957. The highest load factors of the individual power stations so far recorded have been 93.7% for Bokaro 100% for Tilaiya, 98.47% for Maithon and 97.5% for Panchet Hill. Prior to November 1957, BTPS, Tilaiya Hydel Station backed up by some power when required from the thermal power station of


TO PATNA-68M
TO DALMIANAGAR-55M.
GAYA
KODARMA
GIRIDIH
BALMADARI
CABLE FACTORY
TILAIYA
4MW.
BARKAR R.
BARAKAR
NIMIAGHAT
GAHELPUR
G.T.ROAD
132KV
220KV
MAITHON
60MW.
132KV
KUMARDHUBI
DHANBAD
PUTKI
C.T.P.S.
120MW.
RANCHI PLT.
40MW.
BINDRI.
BIRSHADIH.
ROMAR
HAZARIBAGH
B.T.P.S.
225 MW.
ADRA
PURULIA.
ANDAR
RAMGARH
MURI
KHALARI
RANCHI
CHANDIL
TATA
JAMSHEDPUR
MOSABANI
BIHAR.
Note :-
Installed Capacity
Bokaro : 3x50 MW. =150MW. (4 boilers for 3 Turbine)
Tilaiya : 2x2 MW. = 4 MW.
Maithon: 3x20MW. = 60 MW.
Panchet: 1x40MW. = 40 MW.
Total:--- 254 MW.
DATE
No.
DISTRIBUTION
PRINTS
BY
CHKD.
DSGN.
DRWN.
TRCD.
SUB.
368 No.



NOTE:-

Installed Capacity

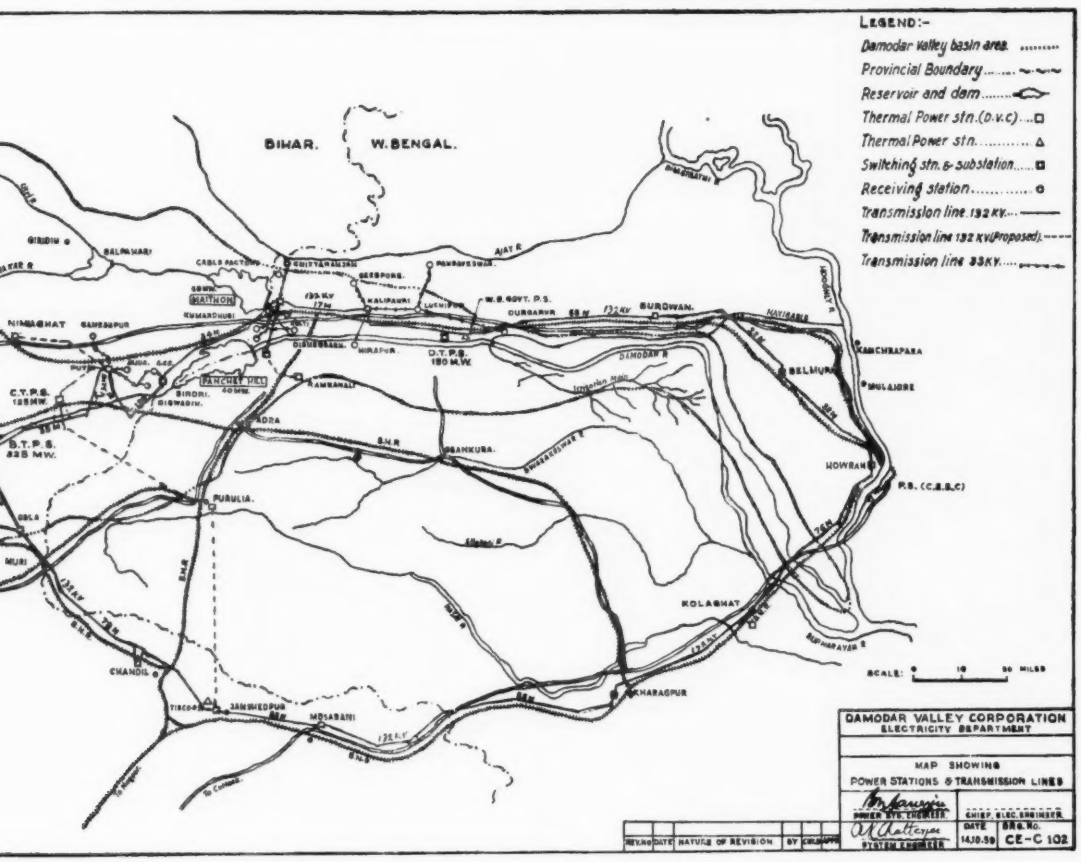
Bokaro : 3x50 MW. =150MW. (4 boilers for 1 Turbine)

Tilaiya : 2x2 MW. = 4 MW.

Maithon: 3x20MW. = 60 MW.

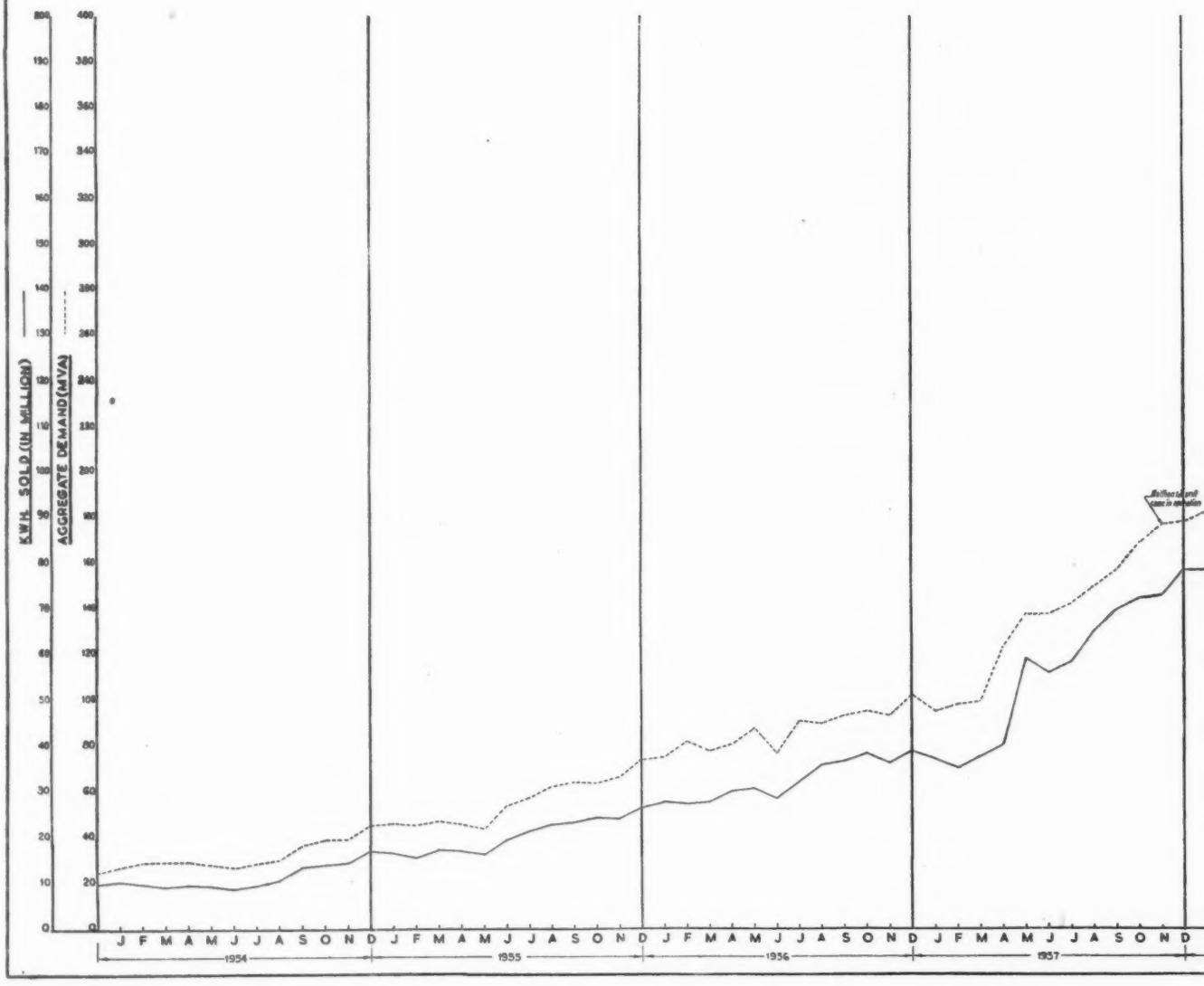
Panchet: 1x40MW. = 40MW.

Total:--- 254 MW.

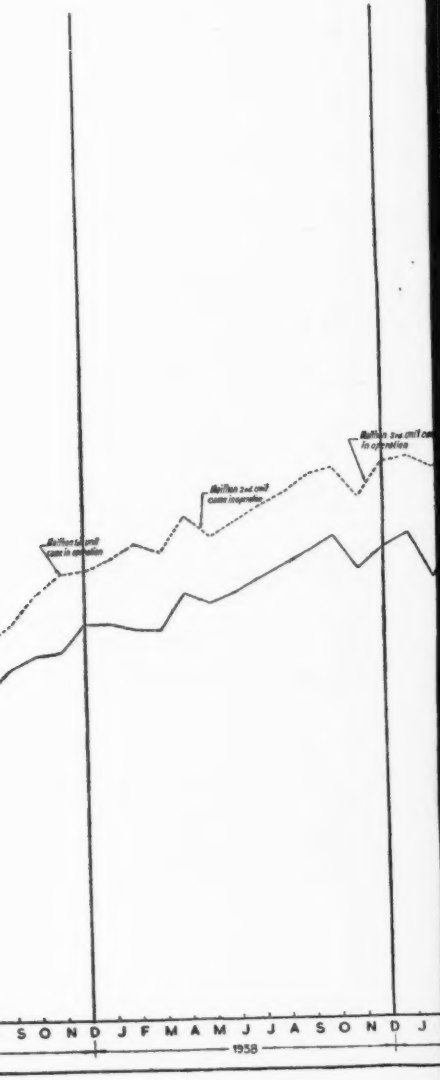

BIHAR.
W. BENGAL.
LEGEND:-
Damodar valley basin area.
Provincial Boundary
Reservoir and dam
Thermal Power stn.(D.V.C)
Thermal Power stn.
Switching stn. & substation
Receiving station
Transmission line 132 KV.
Transmission line 132 KV(Proposed).
Transmission line 33KV.
BIRDIH
BALMUHARI
CABLE FACTORY
GOVT. COLONY
POWERHOUSE
AJAY R.
DAMODAR R.
HOOGHLY R.
50MW. HATINON
132 KV 17M
GEESPORE.
KUMARDHUBI
LUCHIPUR
W.B.GOVT. P.S.
DURGAPUR
88 M
132 KV
BURDWAN.
NAVIGABLE
NIMAGHAT
RANGEGPUR
DIBDIH
MIRAPUR
D.T.P.S.
150 M.W.
DAMODAR R.
KANCHRAPARA
BELMURI
MULAJORE
C.T.P.S.
125MW.
PANCHET HILL
50MW.
BIRDIH.
DIGWADIH.
RAMKANALI
S.T.P.S.
225 MW.
ADRA
S.E.R.
BANKURA.
HOWRAH
P.S. (C.E.S.C)
PURULIA.
KOLAGHAT
CHANDIL
TATA
JAMSHEDPUR
MOSABANI
KHARAGPUR
SCALE: 0 10 20 MILES
DAMODAR VALLEY CORPORATION
ELECTRICITY DEPARTMENT
MAP SHOWING
POWER STATIONS & TRANSMISSION LINES
POWER SYS. ENGINEER
CHIEF ELEC. ENGINEER
SYSTEM ENGINEER
DATE 14.10.59
DRG. No. CE-C 102
REVISIONS DATE NATURE OF REVISION BY CHECKED

D.V.C. POWER SYSTEM.

ACTUAL LOAD DEVELOPMENT FROM 1954 TO 1959



TO 1959



/.C. POWER SYSTEM.

.OAD DEVELOPMENT FROM 1954 TO 1959

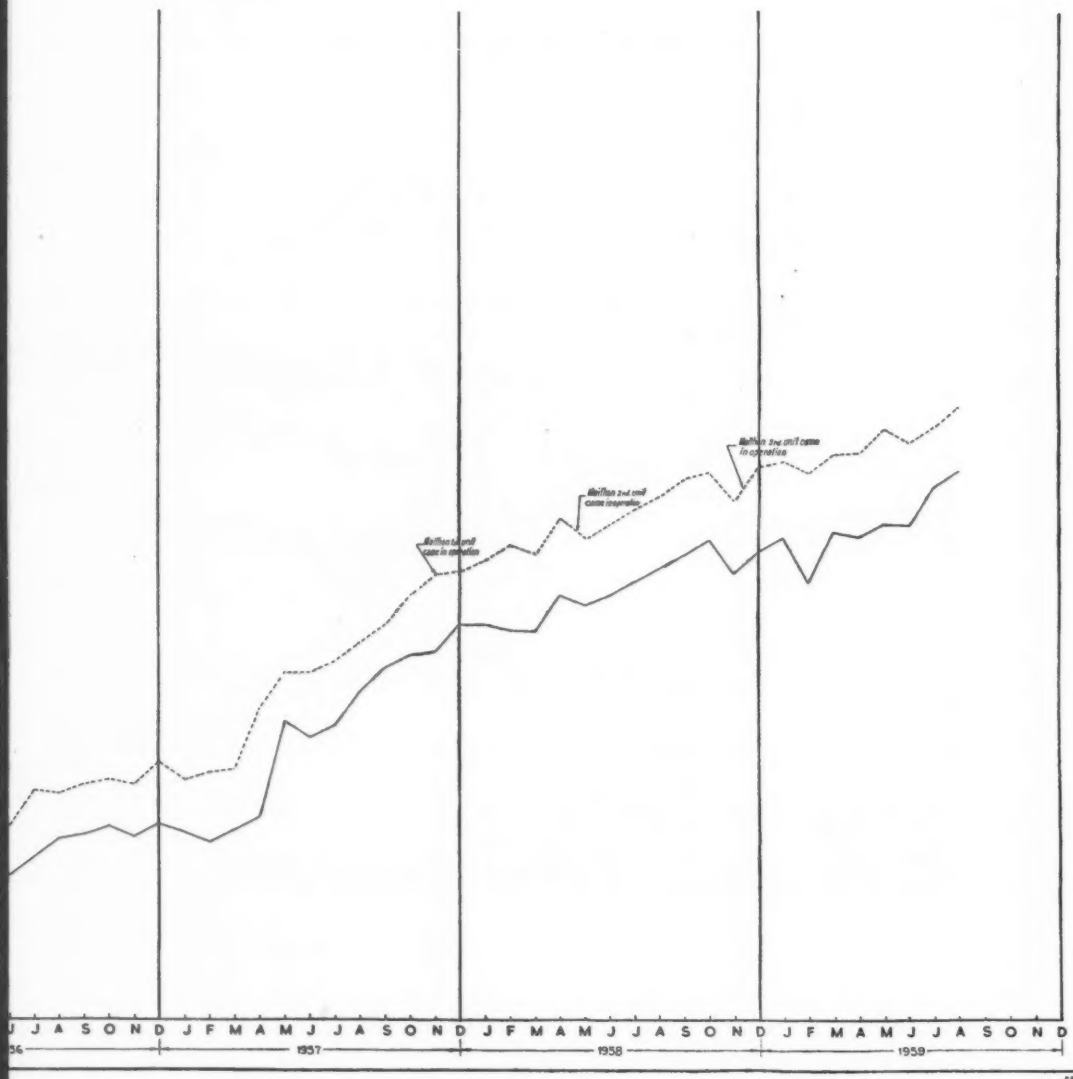
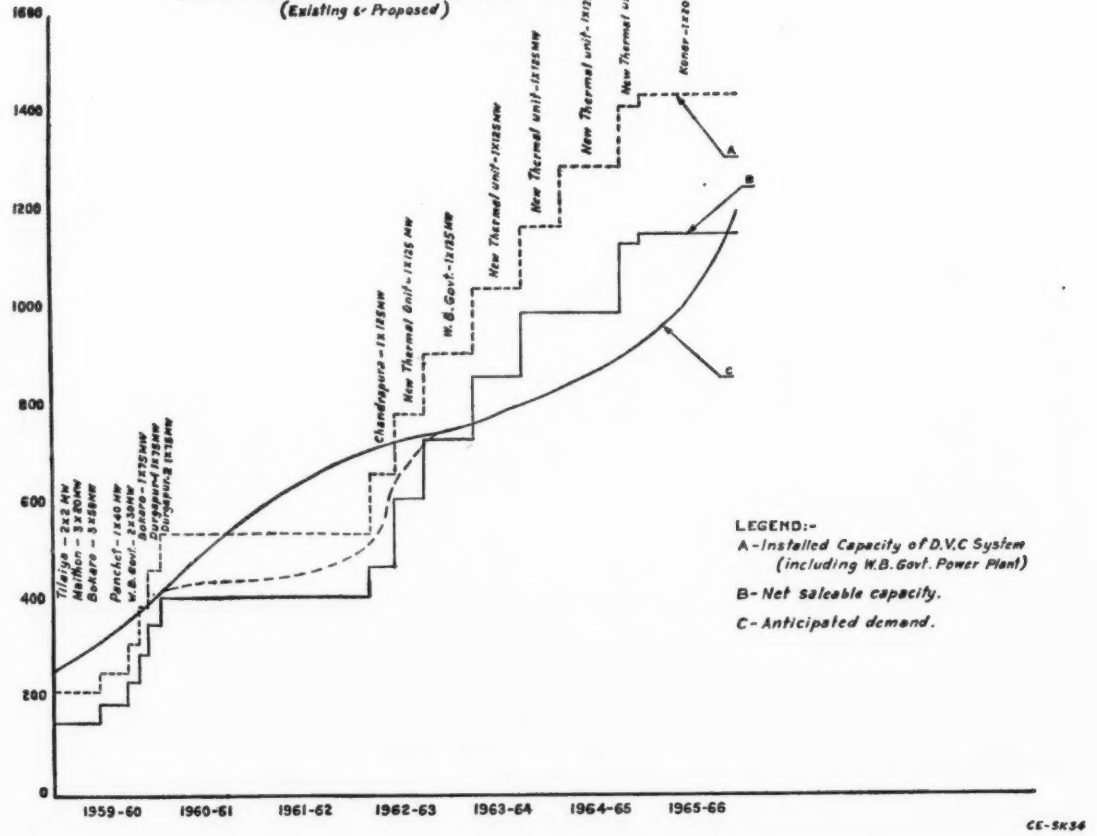

Mattaa 1st unit came in operation
Mattaa 2nd unit came in operation
Mattaa 3rd unit came in operation
J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
56
1957
1958
1959

Exhibit no: 3

D.V.C. POWER SYSTEM

SYSTEM DEMAND AND INSTALLED CAPACITIES

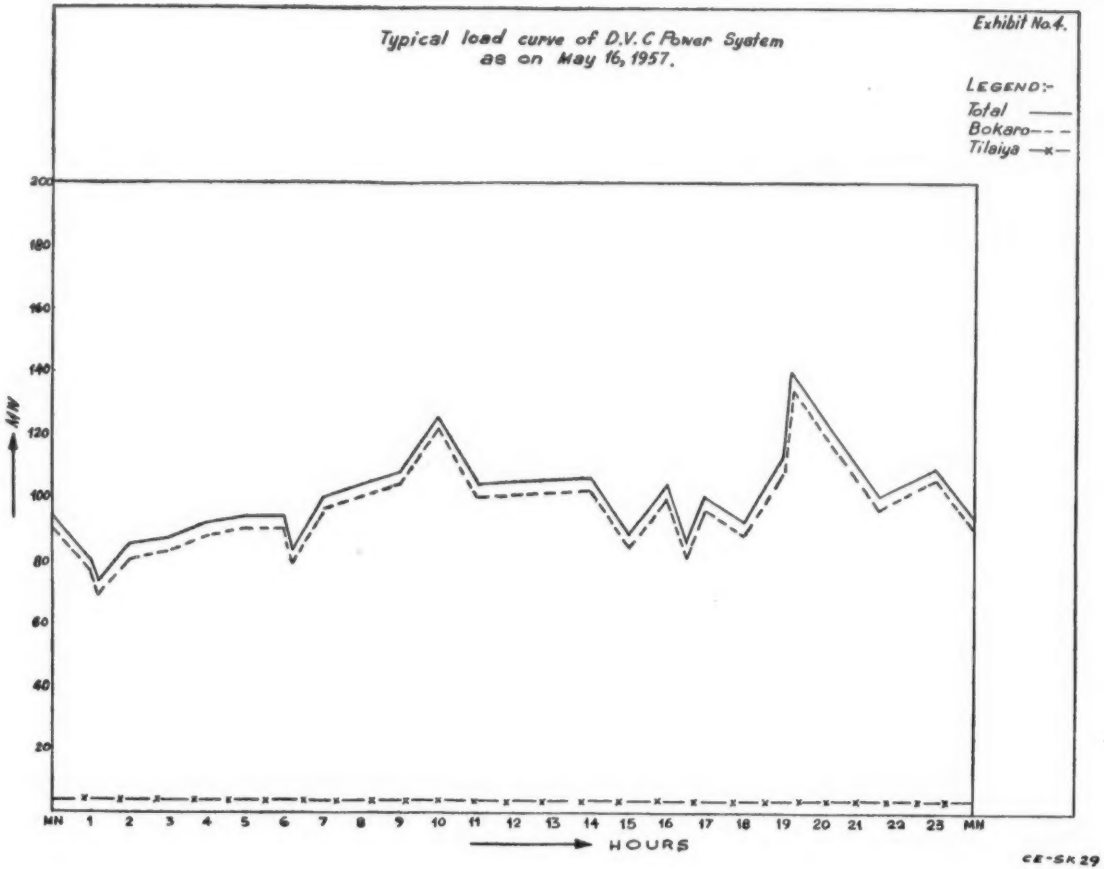
(Existing & Proposed)



CE-SK34

Exhibit No.4.

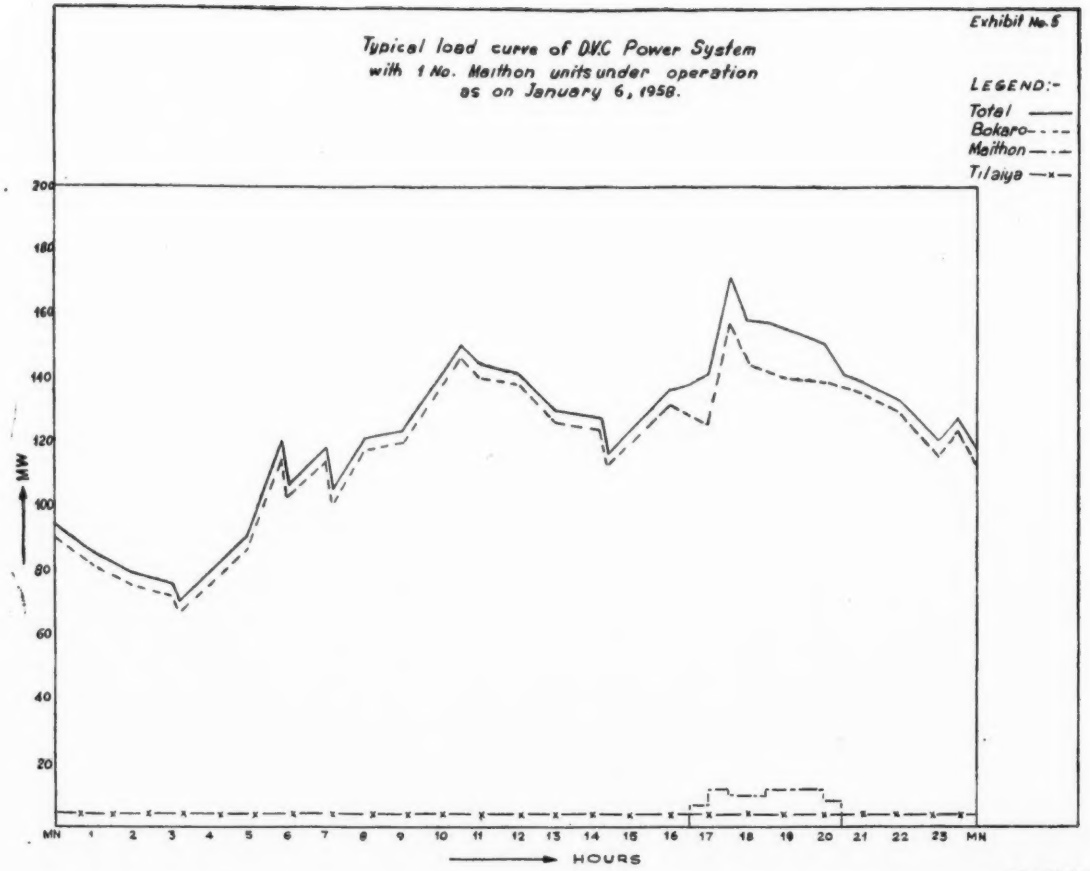
Typical load curve of D.V.C Power System
as on May 16, 1957.



CE-SK 29

Exhibit No. 6

Typical load curve of D.V.C. Power System
with 1 No. Maithon units under operation
as on January 6, 1958.



CE-SK 30

Exhibit No. 6.

Typical load curve of DVC Power System
with 2 nos. Maithon units under operation
as on Sept 18, 1958.

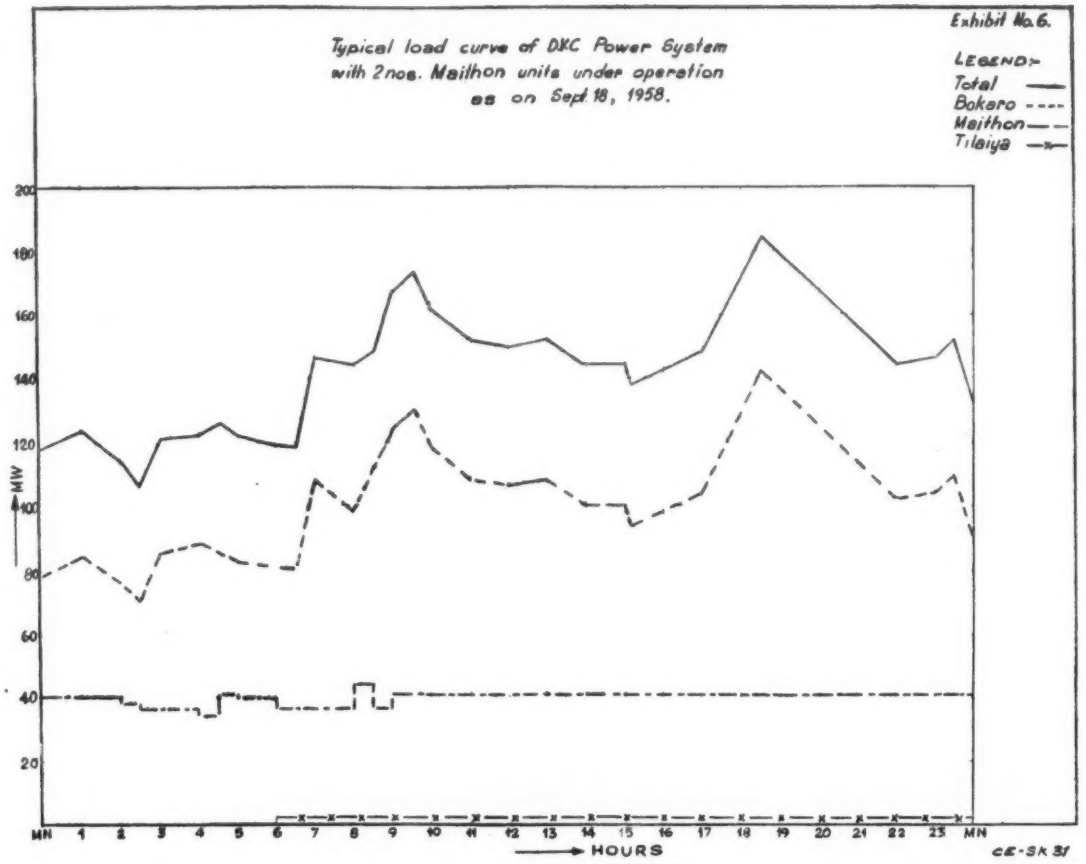
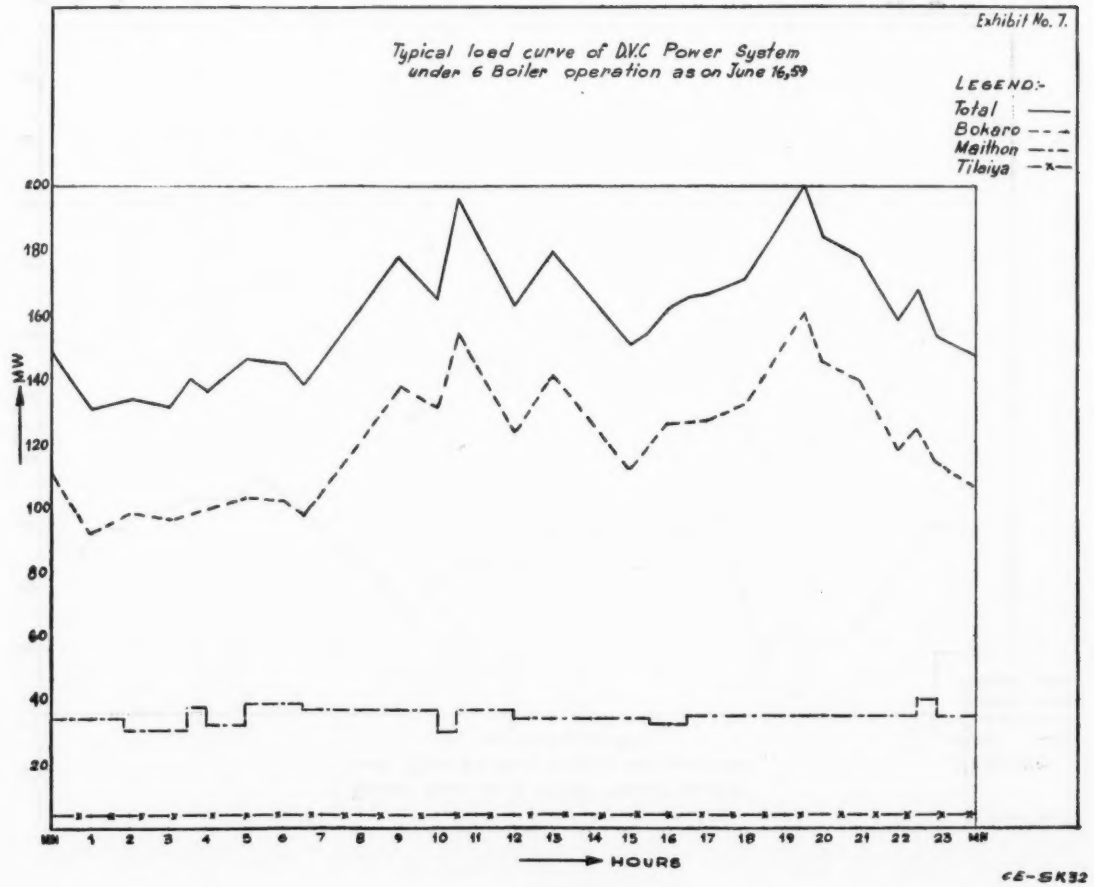


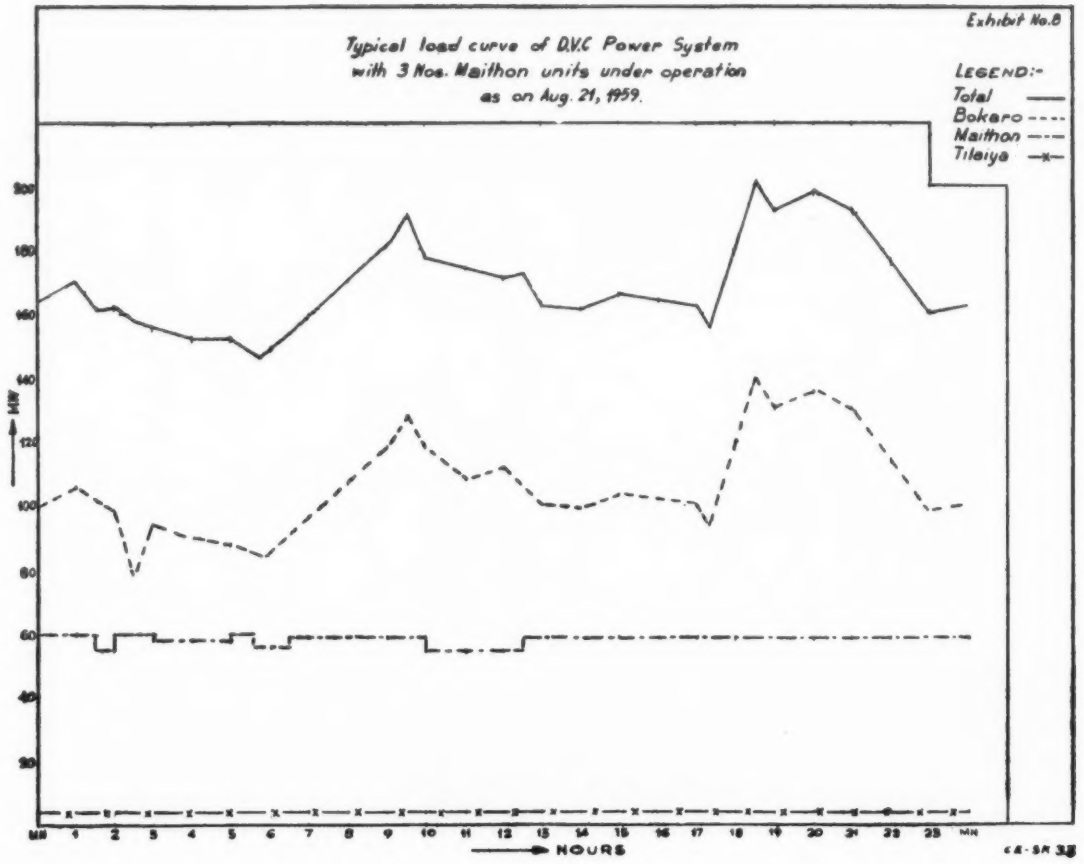
Exhibit No. 7.



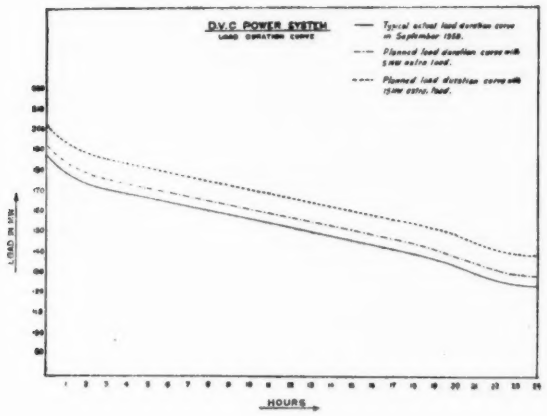
CE-SK32

Exhibit No.8

Typical load curve of D.V.C Power System
with 3 Nos. Maithon units under operation
as on Aug. 21, 1959.



CA-SR 38


D.V.C POWER SYSTEM
LOAD DURATION CURVE
Typical actual load duration curve in September 1958.
Planned load duration curve with 5 MW extra load.
Planned load duration curve with 15 MW extra load.
LOAD IN MW
HOURS

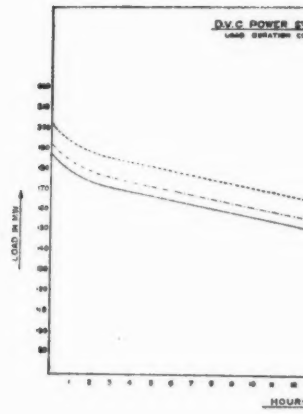
D.V.C POWER SYSTEM

MONTHLY PEAK

AND BOILER OUTAGES

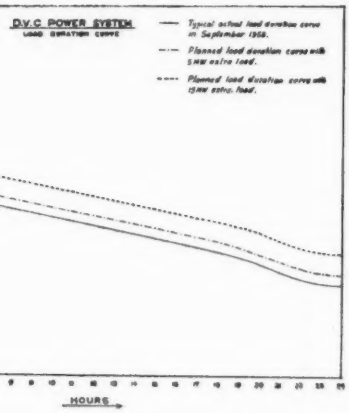
			1957			1958									
			OCT	NOV	DEC	JAN	FEB	MAR	APR.	MAY	JUNE	JULY	AUG	SEP	OCT
BOKARO	UNIT No. 1.	TURBO GENERATOR BOILER NO.1 BOILER NO.2	—	—	—		—	—	—						—
	UNIT No. 2	TURBO GENERATOR BOILER NO.3 BOILER NO.4		—	—	—	—	—	—		—	—			—
	UNIT No. 3.	TURBO GENERATOR BOILER NO. 5 BOILER NO. 6.	—			—	—	—	—	—		—	—	—	
TOTAL FOR THERMAL CAPACITY MW (ACTUAL HALF HOURLY PEAK)			153.5	157.5	159.0	158.0	156.5	153.0	170.0	148.0	168.0	180.5	160.0	163.0	174.5
MAITHON				21	21	20	20	18	20	33	31	35	47	48·5	43
TILAIYA			4	4	4	4	4	4	4	4	3·5	4	4	4	4
TOTAL FOR HYDEL CAPACITY MW (ACTUAL HALF HOURLY PEAK)			24	25	25	24	24	22	24	37	34·5	39	51	52·5	47
SYSTEM GENERATION (ACTUAL HALF HOURLY PEAK)			177.5	188.5	188.5	188.0	187.0	175.0	194.0	184·0	189.5	179.5	184.0	187.5	186.0

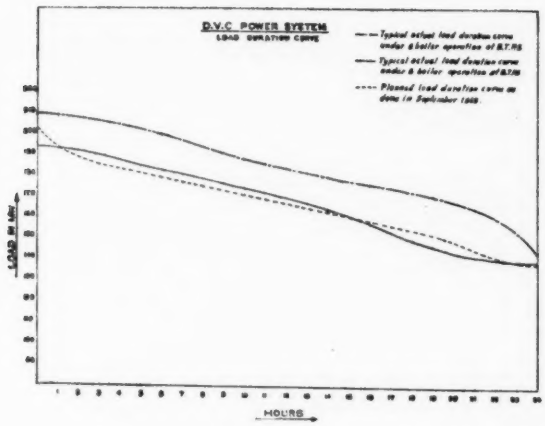
(LEGEND:- Boiler outage ——)



	1957					
	OCT	NOV	DEC	JAN	FEB	MAR
	—	—	—		—	—
		—	—	—		—
	—			—	—	—
MW	153.5	157.5	159.0	158.0	156.5	153.0
		21	21	20	20	18
	4	4	4	4	4	4
KW	24	25	25	24	24	22
	157.5	168.5	168.5	168.0	167.0	156.0

LEGEND:-
Boiler outage ——





D.V.C POWER SYSTEM

MONTHLY PEAK

AND BOILER OUTAGES

Exhibit no. M

	1958											1959							
	FEB	MAR	APR.	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
		-	-			-			-				-		-				
		-			-	-			-	-					-				
		-				-				-	-	-		-	-				
	156.5	153.0	170.0	148.0	168.0	166.5	160.0	163.0	174.5	178.5	181.5	154.5	163.5	157.5	178.5	173.5	169.0	181.0	184.0
	20	18	20	33	31	35	47	48.5	43	37	44	45.5	40	40	51	40	40	57.0	60.0
	4	4	4	4	3.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	24	22	24	37	34.5	39	51	52.5	47	41	48	49.5	44	44	55	44	44	61	64
	167.0	158.0	174.0	166.0	169.5	179.5	181.0	187.5	186.0	181.0	182.0	196.5	198.0	201.5	204.0	207.0	207.0	217.0	222.5

CE-SK 37.

Sindri Fertilizer Factory, were operating in the DVC Power System. Maithan Hydel Station came into operation subsequently, the first unit in November 2, 1957 the second unit in May 21, 1958, and the third unit in December 12, 1958. These hydel units as and when available were operated after carefully working out the water potential left for power generation after meeting the irrigation and flood-control requirements. The demand of all consumers had to be restricted during these difficult years much to the displeasure of the consumers. Some power, however, was subsequently released in stages to the consumers after the 3rd Maithon Unit and the Panchet Station came into operation. This has been possible since the additional thermal units in the DVC Power System are scheduled to come into operation in quick succession soon after the cold season. (Ref. List of Consumers drawing power from the DVC System).

A very critical situation arose in September 1958, when it was examined if about 8 mVA extra power could be released on the face of already existing crisis of power shortage to an important consumer in preference to another, since it became evident that the latter was not ready to take the extra power previously committed to them. In order to insure supply of this extra-power released from March 1959 which was further increased by additional 10 mVA from May 1959, a very careful planning had to be made for the judicious utilisation of water energy available at Maithon and Tilaiya to supplement the base load which could be safely catered by the Bokaro Thermal Power Station under all 3 units (5 boilers) operation. A 'load-duration' curve was worked out on the basis of typical system load curve as obtained in September 1958, then a second set of 'load-duration' curves was plotted allowing for continuous supply of extra 5 mW and a further additional 10 mW power to the above consumer. The required water energy evaluated on this basis indicated a daily average of 250 mW hrs. and 500 mW hrs. approximately. The operation of Maithon and Tilaiya hydel stations was then planned very carefully so that the actual 'load-duration' curve of the system could closely follow the estimated pattern. With further growth of system demand, time came when even five boilers with all 3 turbo-alternator unit operation at BTPS combined with very judicious utilisation of available hydel energy could hardly meet the system demand. The only alternative left was then to resort to all six boilers operation at BTPS from April 1959 thus deferring the annual boiler overhaul and inspection by the Government Inspectorate with the permission of the State Government concerned. This mode of operation allowed for the minimum, but far below adequate 'hot' reserve so that increase of minor emergency or short-time peak, the situation could be overcome by the marginal spinning reserve without affecting the system voltage and frequency. The estimated load duration curve and the actual ones during the period 1958-1959 are shown in Figs. 10 and 11 under 5 and 6 boilers operating conditions at Bokaro.

Load shedding schedules had also to be worked out to meet eventualities during these trying years of operation, but fortunately, no major load sheddings worth mentioning had to be resorted to up-till date except for short durations under arrangement with the consumers. There have been minor adjustments of load during these years to overcome operation and maintenance troubles experienced at Bokaro and other part of the System. The maximum overload capability of the installed plants at Bokaro, much in excess of their name plate ratings, often came to rescue. Operation of the system by allowing a negligible drop of voltage and frequency has also been adopted on a few occasions to tide over difficulty. There have also been a few cases of breakdowns of lines, transformers and other electrical equipment in the Transmission and Distribution System due to lightnings, cyclone, and other hazards but these have been promptly repaired by the Grid Operation and Maintenance and the Central Services Organisation of the DVC without appreciably affecting the system demand.

Operation of the existing units each comprising two boilers and a turbo-alternator set at Bokaro during these crisis years proved to be of immense help since it allowed for continuous operation of all three turbo-alternators even though the boilers and the auxilliaries suffered through a number of minor outages under unavoidable circumstances. The reliability of the present turbo-alternator sets has also been proved beyond doubt. These units after the last overhaul have already operated very satisfactorily 26280 (No. 1 unit), 29800 (No. 2 unit) and 27720 (No. 3 unit) hours upto September 30, 1959, while the normal operating hours between inspections/overhauls of such machines do not exceed 8,000 to 10,000 hours. Fig 12 shows the outages of boilers and the actual system generation during the period October 1957 till August 1959. The unusually satisfactory performance of the installed units operating at the Bokaro Thermal Power Station should not be taken as a general rule while provision of adequate reserve capacity is considered for safe operation of a large and growing power system like that of the DVC. This abnormal mode of operation becomes a necessity in trying time, but it should not be allowed to continue for long as even the very best machine can breakdown for want of desired thorough overhaul requiring comparatively long outage. The earlier the long overdue overhauling of the Bokaro sets is taken in hand the better assured will be the security of the DVC. Power System. But relief to these overworked machines can be afforded in rotation only after additional thermal plants come into operation. The extremely serious power shortage which has commenced in 1958-59 can be overcome, if the DVC's schemes of additional generation and reinforcement of transmission system are put through on urgent basis. The other alternative would be the

restriction of industrial and other developments in the Valley thus putting a stop to the increasing system demand. Fortunately, the DVC Power System has so far been able to tide over the difficult years without any untoward incident but behaviour of all machines under similar conditions cannot always be safely predicted. The newer plant and equipment had to be rightly selected giving due consideration to the competetive offers received against global tender accepting the required specifications and performances guaranteed by the manufacturers. It has to be recalled that very valuable operation and maintenance experience was gained by the operating staff at the time of initial low load operation of the Bokaro Thermal Power Station when the reliability of each of the installed plant and equipment gradually established itself under varied conditions. This will not be possible with the new plants and equipment under present load condition. It is, therefore, vitally important that from now onwards adequate reserve is provided to cover both scheduled and forced outages of the thermal units and thus ensure safe operation of the entire Power System.

LIST OF CONSUMERS IN THE DVC SYSTEM

1. Associated Cement Co., Sindri.
2. Associated Power Cos. Ltd.
3. Bihar State Electricity Board.
4. Calcutta Elec. Supply Corporation, Howrah.
5. Chittaranjan Locomotive Works.
6. Durgapur Coke Oven (Government of West Bengal).
7. Dishergarh Power Supply Co. Ltd., Kumardhubi & Dishergarh.
8. Durgapur Steel Project.
9. Eastern Railway.
10. Hindusthan Cables, Rupnarainpur.
11. Indian Copper Corporation, Mosabani.
12. Indian Iron & Steel Co.
13. Sijua Jheria Electric Supply Co.
14. Tata Iron & Steel Co. Ltd., Jamshedpur.
15. West Bengal State Electricity Board.

What are Durajoint & Duraseal? Where are they used? What are their advantages? Why are they specified by so many construction engineers?

M & I have prepared a booklet containing the answers to these and many other questions about Durajoint and Duraseal. Experience shows that they are ideal materials for expansion and construction joints in concrete, and if you'd like some facts and figures, write or 'phone for a copy of "Durajoint and Duraseal"; it is packed with useful information.

There is nothing quite like Durajoint and Duraseal

Agent for North India: S. LAUL & Co., 15/21 Civil Lines, KANPUR, and 10 Alipur Road, DELHI. Tel: Delhi 25208.
Agent for South India: MODI & MODI, P.O. Box 293, 11 Linghi Chetty Street, MADRAS, 1. Tel: Madras 3096. (Madras, Mysore, Andhra, Travancore-Cochin and Coorg.)

THE MICANITE & INSULATORS CO. LTD.
Blackhorse Lane, Walthamstow, London, E.17
Cables: Mytilite, London. Telex: 25183

Irrigation Potential of DVC Project and Its Problems

S. R. GHOSE
Deputy Chief Engineer,
Barrage and Irrigation, DVC.

ONE of the three main objects of Damodar Valley Project is to supply water for purposes of irrigation. The topography of the upper valley is such that local irrigation from water stored in the reservoirs is not feasible consistent with economy. The benefits of irrigation are thus mainly confined to the lower valley where the land is flat and fertile.

The Durgapur Barrage which is the core of the irrigation system is designed to supply water for kharif irrigation to 10,44,000 acres of land. The network of canals which will be fed from the Durgapur Barrage consists of 140 miles of main canals, 98 miles of branch canals, 952 miles of distributaries and 360 miles of drainage channels. There will be nearly 1800 structures, big and small, in a total length of 1,550 miles of canals scattered over four districts of Howrah, Hooghly, Burdwan and Bankura. The Project also envisaged rabi irrigation to about 3 lakh acres of land out of a total of 5 lakh acres fit for rabi crops.

The Durgapur Barrage, the construction of which was started in October, 1952, was completed in April, 1955. The excavation of canals and associated distributaries was so phased that irrigation could be extended progressively along with the completion of Durgapur Barrage and Dams in the upper valley. Notwithstanding that the working season is hardly 6 months each year, the major portion of earthwork on main canals and branch canals is almost complete and distributaries and drainage channels are also substantially complete. The progress in respect of major structures has been equally encouraging, but owing to paucity of reliable contractors and for difficulties in supply of cement and steel, want of access roads, difficulty in getting wagons etc., about 150 minor structures still remain to be completed.

The estimated cost of the Barrage and Irrigation Project including the cost allocable to navigation is Rs. 22.86 crores. The expenditure so far incurred is a little over 18 crores. On a recent review of the position it is anticipated that the Project will be completed within the estimated cost.

In the year 1956, water was supplied to about 46,000 acres of land. The rate of water agreed upon was Rs. 7.75 per acre of land and supply was made available only to lands for which lease agreements were executed. The distribution of rainfall in 1956 was good and so very few leases were executed. Besides, when agreements were executed for blocks at the tail end of a distributary and the canal had to flow, there was a tendency to resort to unauthorised cuts to irrigate the blocks at the head without any payment of water rate nor execution of agreements. It was admitted by the Irrigation & Waterways Department, West Bengal, that the actual area irrigated far exceeded the figure mentioned above.

In the year 1957, the D.V.C. canals were ready to extend irrigation to approximately 1,92,000 acres. In order to demonstrate the benefits of irrigation to the people, it was decided to supply water, free of charge. The response was extremely encouraging and demand for water came from all quarters. The actual area irrigated during the year was, however, only 1,43,000 acres, owing to damages caused to some of our canal structures by the 1956 flood. Some crop cutting experiments were conducted both in Burdwan and in Bankura Districts in collaboration with the cultivators. Although the results of these experiments cannot be regarded as conclusive in absence of proper scientific and statistical control, they are sufficiently indicative of the potential benefits of irrigation. The *extra* yield of paddy and straw per acre in the newly irrigated area in Burdwan District was reported to be 12.1 mds. and 20 mds. respectively. In Bankura District, yield of paddy and straw per acre for irrigated and non-irrigated areas was as follows:

	Paddy	*Straw*
(i) *Non-irrigated area*	21 mds.	34 mds.
(ii) *Irrigated area*	48.1 mds.	57.3 mds.

These experiments were carried out in Belgaria, Suratpur and Palasdanga mouzas.

In 1958, the old Damodar Canal System was merged with the D.V.C. canals and water for assured irrigation was supplied from Durgapur pond replenished through releases from Maithon dam as and when needed. The potential for kharif irrigation had increased to 5,16,000 acres to which, later, an area of 50,000 acres likely to receive irrigation by rotation was added. Being the first year when such extensive irrigation from new canals was proposed, various difficulties were encountered in the operation of canals. Canals were new and required soaking, staunching, stabilisation and testing. Operational staff were inexperienced. Quick movement was not

possible as inspection paths were not ready. Intercommunication system through canal telephone lines was not complete. Co-ordination was difficult. In spite of all these handicaps, reports indicated that the actual area irrigated was 4,88,000 acres. The short fall was mainly due to a smaller extent of cultivable land within the command of Panagarh and Durgapur Branch Canals.

The development of kharif and rabi irrigation in future years may be expected as under:—

Year	*Kharif*	*Rabi*
	acres	acres (including 6000 acres existing)
1959-60	6,00,000	7,000
1960-61	8,00,000	10,000
1961-62	9,00,000	50,000
1962-63	9,50,000	90,000
1963-64	10,00,000	1,30,000
1964-65	10,00,000	1,40,000
1965-66	10,00,000	1,50,000

It will be seen that the development of Rabi Irrigation as forecast is rather slow. This is so because the cultivators will require a great deal of convincing before they change their crop pattern. According to the water management plan recently prepared, the four dams constructed so far are in a position to guarantee a minimum supply of only 500 cusecs of water for Rabi Irrigation which is adequate for only 1,00,000 acres of Rabi. It is estimated that there are about half a million acres of land fit for Rabi cultivation provided water supply can be assured during the dry months. One more dam across the Damodar in the Upper Valley is absolutely necessary and it is accordingly proposed to press for the early construction of Aiyar Dam.

Irrigation from Right Bank Main Canal received wholehearted co-operation and assistance from the beneficiaries and there was no interference with the operation of regulator gates and outlets, whereas, in the Left Bank System, cases of interference, surreptitious cuts and attempts to divert or hold water in a manner opposed to the best interest of the beneficiaries were noticed. Instances of pilferage and theft of gate parts and playful damage to canal structures were numerous. No doubt more publicity is needed to awaken the conscience of villagers against such malpractices but some punitive measures are essential where the short arm of the ordinary law does not act as a deterrent.

Under the Act, the D.V.C. is to supply water in bulk to the West Bengal Government and the State Government is responsible for its distribution and fixation and realisation of water rate from cultivators. The Act does not provide how and where the bulk supply is to be measured. As the canal system is owned by the DVC it was previously agreed that demand for water would be placed by the Irrigation & Waterways Department and control of distribution upto outlet end would devolve on the DVC. This arrangement, however, did not work satisfactorily for lack of co-ordination and understanding at lower level. Besides, the DVC had no law and order powers to enforce its decisions. Furthermore, the arrangement was not economical as there was duplication of staff and duplication of work. It has been mutually agreed that dual control should be dispensed with and the D.V.C. has accordingly made proposals to the West Bengal Government for handing over the operation and maintenance of the canal system to the State Government, with whom the matter is still pending.

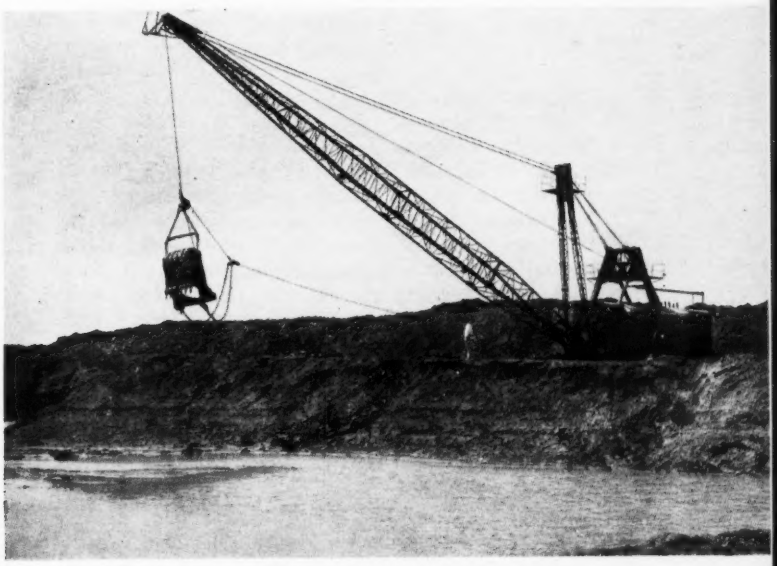
The total requirement of water for Kharif Irrigation has been accepted as being 40 inches. Canal take-off worked out for eight typical years on the above basis indicated that delta at the canal head varied between 11.5 inches to 19.7 inches for the crop period as a whole. The actual take-off in the old Damodar Canal System during the past 24 years gives an average of 21.7 inches varying from a minimum of 6.4 inches to a maximum of 28.7 inches. The corresponding figures for the Mayurakshi system based on 4 years' data are 15.7 inches average, with a minimum of 12.5 inches and a maximum of 20.2 inches. The actual take-off in the old Damodar Canal System is definitely on the high side. It is explained by people's anxiety to draw as much water as possible while there was water in the river as the Rhondia weir was dependent on river discharge alone and had no assured supply from dams and reservoirs. If wasteful habits are curbed and field channels are constructed much economy could be effected in the over-all consumption of water.

The present system of conveyance of water to irrigable areas is by inundation from field to field. Very few village channels now exist and there is no noticeable enthusiasm displayed by cultivators to construct these essential village channels. As a result, there is much difficulty in equitable distribution of water. In times of scarcity of water, irrigation in respect of plots of land, away from the outlets is dependent entirely on the good sense of the villagers owning plots nearer the outlets and often these lands are deprived of water when they need it most. On the other hand, when water is available in plenty, the upland cannot avoid over-irrigation if the land below is to receive just enough. It is, therefore, essential that the State Government immediately undertakes the construction of the village channels as persuasive methods cannot be expected to achieve any progress in this direction. This is of paramount importance as, otherwise, during the critical period of short rainfall during September and October, there will be shortage of water and tail end lands will receive no supply.

With the introduction of assured irrigation the crop pattern is likely to change and results of crop experiments undertaken by the State Government

Head regulator, Durgapur Barrage.

Canal excavation in progress, DVC.



Left Bank Main Canal, DVC.

and the Panagar Experimental Farm, should be given proper publicity so that the cultivators may profit by such knowledge. In West Bengal, the main Kharif crops are paddy and jute, while potato, mustard, pulses and vegetables are the Rabi crops. Sugarcane is practically a whole year crop. Potato is generally planted between September and November. The fields growing Aman paddy are not, therefore, likely to produce potato as a second crop as harvesting of late Aman is continued till middle of December. It is, therefore, necessary to introduce the cultivation of early-Aman or transplanted-Aus in order to raise a second crop of potato in the same fields. Another important aspect which needs careful attention is that due to assured irrigation the crop pattern may change predominantly in favour of late-Aman, which is more productive and yields a better return. If it so happens, double cropping will practically be eliminated. If use of water could be rationalised, it might be possible to supply water for early Aman or for jute from middle of April. A delta of 7″ to 9″ will, perhaps, be sufficient for these early crops. This aspect is also being studied with reference to the water management plan.

In an irrigation project the benefits do not accrue to all the lands through which the canals pass. Although the alignments are so chosen that the maximum command can be served, it is not always possible due to topographical conditions. In the head reaches, a considerable length of the canal is usually unproductive. The people who own the land have to agree to acquisition of land for canals even when they do not derive any benefit. This brings about dissatisfaction and sometimes staunch opposition to execution of irrigation projects. Besides, it has been noticed in certain reaches that the natural drainage line is intercepted by the canals and quite a good stretch of land is deprived of the natural irrigation during rainy season as the drainage finds its way into the canal through inlets. If such lands are out of command, it is essential that some arrangements for lift irrigation be provided at a cost commensurate with the water rate adopted for other areas. This will go a long way to restore the good-will and cooperation of land-holders who are otherwise prone to object to the scheme.

Another point which deserves considerable attention is the location of bridges. Excavation of a canal cuts off the existing communication link in some places. It is not possible to provide bridges on every such village road as the cost of the project would be prohibitive. Even if the bridges are suitably spaced, public grievances cannot be entirely eliminated. Detouring of $1\frac{1}{2}$ to 2 miles may not be a tough job for a villager but a request to the villagers to agree to put up with such inconvenience is very seldom accepted with good grace. The benefits of an irrigation project are usually assessed in terms of extra yield of crops, but the extra cost of cultivation is rarely taken into consideration in the comparison. Sometimes considerable man-hours are lost in travelling greater distances with bullocks and ploughs and the cost of cultivation correspondingly goes up. If any holding is thus found uneconomical it changes hands usually at a depreciated rate. Such losses in transactions of land should be taken into account in the project estimate and wherever possible the land-holders should be compensated. This will eliminate public opposition to a great extent.

Development of irrigation is a socio-economic promlem. The habit of making the best use of water has to be imbibed by long usuage. Proper land use and management have to be taught and is a slow process. Experimental farms may help in guiding the cultivators to adopt the right type of crops, improved seeds and better manure. Rotation of crops as a means to improve the fertility of soil has also to be studied with reference to soil condition, duration of crop and economic barometer or the price level of different crops. Crop competitions on a comprehensive scale may go a long way in creating a more lively interest in production. A higher standard in production of crops is certainly to be encouraged in the context of the country's food shortage. Although available data in India is not very comprehensive, there is no denying the fact that yields of principal food crops like wheat and rice are considerably smaller than those obtaining in Japan and China. There is every sign to indicate that villagers are becoming more and more actively interested in improved methods of agriculture and we hope that in very near future the benefits of irrigation combined with agricultural advancements will be able to reduce the margin of food deficit which has been a concern to the State Governments for the past few years.

INDIAN JOURNAL OF

POWER & RIVER VALLEY DEVELOPMENT

SPECIAL NUMBER ON

RIHAN HYDRO-ELECTRIC PROJECT

Navigation Canal Scheme

By A. K. SEN GUPTA,
Executive Engineer,
Damodar Valley Corporation

IT was in the earliest Voorduin's report that the possibility of navigation through some of the major irrigation channels was visualised, connecting the coal field areas near Raniganj with Calcutta. The technical advantage inherent in the irrigation scheme combined with the problem of the transport of coal to Calcutta very rightly contributed to the opening up of a new and important water route in this area.

Voorduin's recommendations, with large variation in technical details, have since been worked out, and the barrage has actually been located near Durgapur instead of at Silna as recommended by him, but the navigation potentialities of the new irrigation canal stood on the same advantageous footing. The bigger of the two canals emerging from the barrage at Durgapur, the Left Bank Main canal of the irrigation system, has thus been designed as an irrigation-cum-navigation canal. In fact, navigation is also feasible on the right bank main canal and may in the near future develop significantly to harness the rich quarries of Bankura on the other side of the river. The canal has been made negotiable with the river through a lock. The left bank irrigation-cum-navigation canal after a run of nearly 85 miles meets the river Kunti and after a further run of two miles through Kunti connects up with the Hooghly. From this junction with the Hooghly, Calcutta is only about 35 miles. The irrigation-cum-navigation canal has been aligned more or less parallel to the Grand Trunk Road and the Eastern Railway Main Line and is thus expected to relieve congestion of both rail and road traffic. Based on the irrigation requirements the width of the canal at bed varies from 172 ft. at the head to the minimum requirements for navigation purposes of 60 ft. at the tail end. The canal is designed to maintain a clear depth of 12 ft. during Kharif season i.e. July to October, while for the rest of the season, by merely ponding up the different reaches between the locks in the canal, the minimum depth of water upto 8 ft. can be maintained. A clear headroom of 17 ft. from the maximum water level has been provided below the bridges. The provisions made in the canal will therefore allow craft of 6 ft draft to ply conveniently through it.

The general slope of the country from Durgapur to near Tribeni, where Kunti has its outfall into the Hooghly, is about 3 ft. per mile. This slope would induce far too great a velocity in the canal intended for navigation. A navigation canal should be as flat as possible. Even with a slope of 0.125 per thousand i.e. about 0.66 ft. per mile, which has been provided in the canal, the velocity induced would be bordering 3 ft. per second, which is the maximum permissible for navigation. For these obvious reasons, therefore, the canal has been terraced down with vertical falls with about 4 mile stretches and the navigability has been maintained at these drops through locks.

There are altogether 23 locks in the whole stretch of 85 miles including the one at Durgapur, construction of which has been necessitated out of water supply requirement for steel and other industries near Durgapur.

Based on provisions actually made in the navigation locks in the Europe and elsewhere the net width of the lock chamber has been kept at 20 ft. The width of the locks of St. Martin Canal in France is 5.2 Metre i.e. 17.3 ft. and that of Lahu River (canalised) is only 5.55 Metre i.e. 17.38′. The lock chambers in the DVC Navigation Canal will allow barges upto 18 ft. wide to negotiate. Such Barges can conveniently carry a pay load of 200 tons. Mitre type steel gates have been provided in the locks and the manually operated locks will take not more than 30 minutes for each operation. This comprsies of the following:

Time required for the vessel to pass the approach channel	...	10 minutes.
Time required for the vessel to pass the exit channel	...	8 „
Time required for filling or emptying the locks	...	12 „
		30 minutes.

From the present day requirement, the canal has been designed to carry traffic of 2 million tons annually during its both upward and downward journeys, out of which coal alone is estimated to contribute 1 million tons. It has been estimated that, with the locking time of 30 minutes, single locks should comfortably meet the estimated traffic of 2 million tons a year. Implementation of electrical control arrangements of the lock gates at the first instance and duplication of lock chambers will go a long way in enlarging the canal capacity for any future requirement. In the opinion of several experts, the bottleneck for through navigation would lie in the number of locks in the canal and the bars at Hooghly. Careful studies have been made to determine the effect of these on the average turn-round time. It is assessed that the average turn-round time will not be more than 9 days to cover loading, un-

(Continued on page 10)

Modified Butterfly type Undersluice Gate, as adopted in Two of the DVC Dams

By S. S. Rao,
Project Officer, Maithon, DVC

A new type of gate for the control of flow in the river outlet conduits was originated in 1951 by the late President L. F. Harza of the Harza Engineering Co., Chicago, U.S.A., who were the Consulting Engineers for the Maithon and Panchet Hill Projects of the Damodar Valley Corporation. Three such gates, two at Tilaiya dam and one at Panchet Hill Dam, have since been fabricated and installed by the DVC. The one at Panchet Hill is for a Sluice 10′-0″ high by 5′-8″ wide on the downstream side of the gate and those at Tilaiya are for a sluice 3′-4″ high by 1′-11″ wide on the downstream side of the gate. The speciality of this gate is that it dispenses with all the complicated arrangements of mechanical hoists for its operation but instead is operated hydraulically by utilising the hydrostatic head of the reservoir itself. This special feature contributes to its simplicity of construction and easy operation. An attempt is made herein to explain briefly the salient features of this gate as well as its operating principle.

GENERAL FEATURES

The gate consists chiefly of a single leaf mounted on to a vertical shaft such that the leaf forms two unequal arms. The unbalanced hydraulic pressure on this extra arm length on one side brings about the movement of the gate. The portion of the conduit where the gate is installed is lined with steel plates at the bottom, top and sides, known respectively as bottom liner, top liner and side liners and are suitably strengthened with stiffeners. Of the two side liners, one is curved, being an arc of a circle, and the other is a straight one. The liners when assembled form into a sort of a steel chamber in which the gate is housed. The gate is a completely welded structure and has a steel hub on the side opposite the skin plate. In order to make the gate completely watertight, rubber seals are provided on the sides, top, bottom and on the hub of the gate which are all subjected to the reservoir hydrostatic pressure or the pressure of a high level water system whenever perfect sealing is desired. The gate leaf has been so shaped as to cause a stream line flow in the conduit. The gate shaft already mentioned above is held in position by the bearings at top and bottom. The bottom bearing is housed in a cylindrical chamber which forms a part of the bottom liner, and the top bearing is housed in a gate cover which in turn is bolted on to the top liner.

DESCRIPTION OF PARTS

The gate consists of liners, gate leaf, gate cover, and head water supply and drains as its principal parts. A brief description of each is given below:

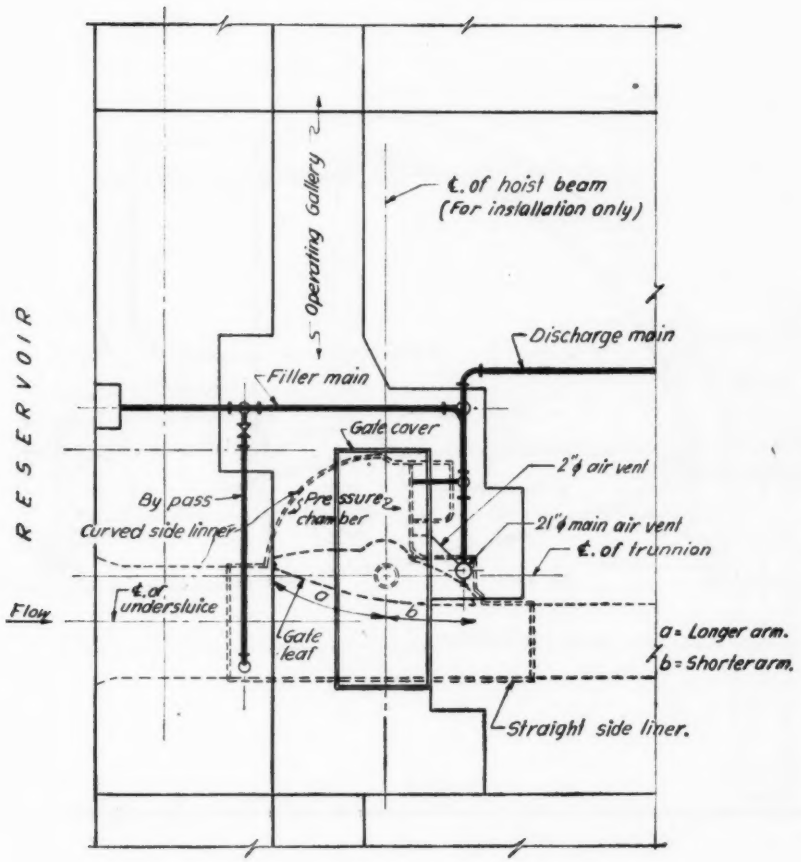
Plate liner:—As already stated above, the assembly of the plate liner consists of top, bottom and side liners. The plate liner is of welded steel and is stiffened by means of welded plates to form ribs. Attached to the liner are the lower main gate bearing, the headwater supply line, upper drain and lower plug drain, the fixed vertical gate seal or the chamber seal, levelling bolts, hold down rods and grout holes.

The liner has to be assembled at the dam site and is held rigidly is shape by means of spider webs welded inside. The handling is done in such a manner as to insure no distortion of the liner.

Gate leaf:—This consists of a welded steel plate leaf with flanged plate ribs—horizontal and vertical — to stiffen the leaf as well as to transmit the load. In the case of the gate at Panchet Hill, a 15 inch diameter sleeved shaft extending through the leaf and bolted to the top and bottom ribs carries the loads to the bearings.

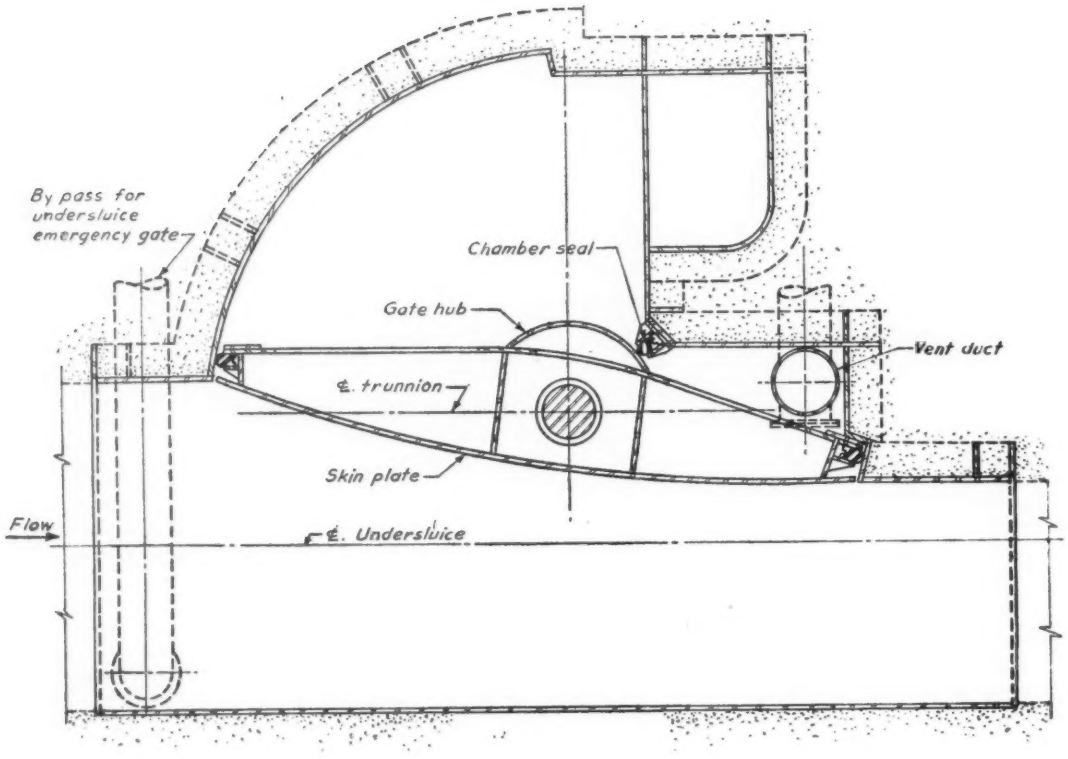
The gate is mounted off-centre on the shaft. At any time that no back pressure exists on the downstream face or when the back pressure is reduced enough, the gate will move to a closed position. Admitting headwater into the pressure chamber with the drain valves closed, the pressure on the larger portion of the gate leaf is equalized and the gate moves to an open position.

The gate seals are mounted on the downstream face of the gate and can be inspected without unwatering the upstream chamber. The seals are vulcanized into one continuous piece and are held on the gate leaf through bolting with what are called keeper plates which are actually stainless clad steel plates. These keeper plates are made in sections for easy removal, and are so made that each section fits against the other as close as possible to produce as perfect a water tight joint as possible. The keeper plates are bolted to the gate with brass bolts. At any future date, should it become necessary to remove the gate seal, it can be done by first removing the keeper plates. The rubber seal is then cut at one point and removed. A new rubber seal can then be inserted in its place.



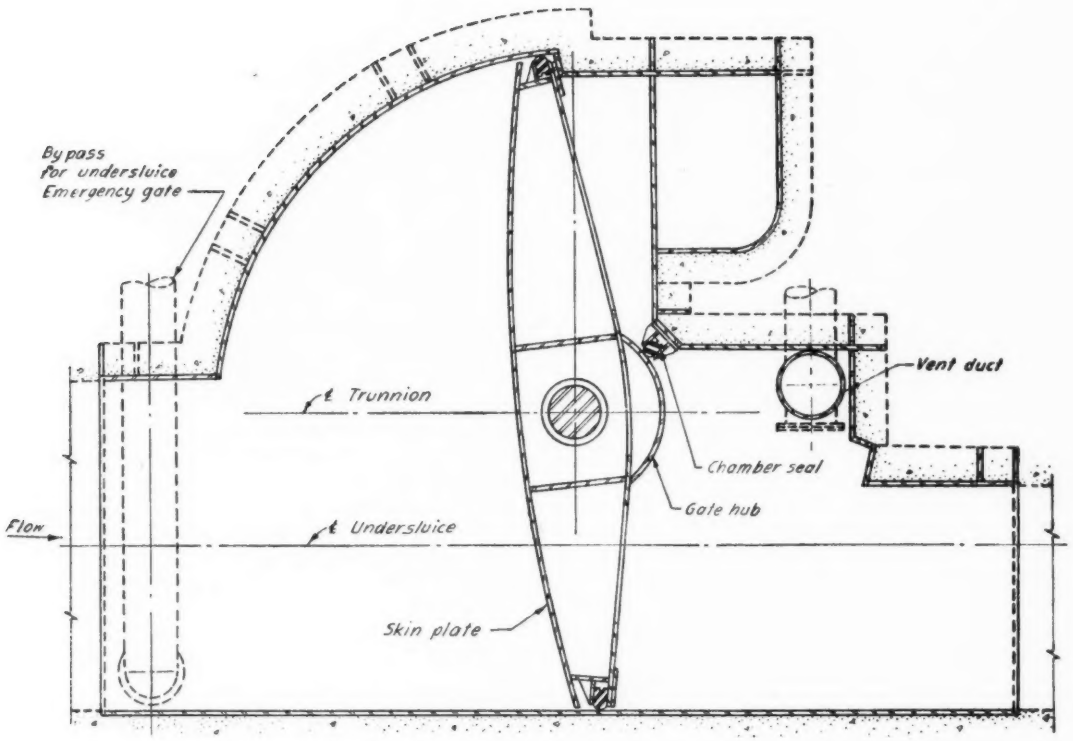
General arrangement of the modified Butterfly type gate as seen from the operating gallery.

SKETCH I



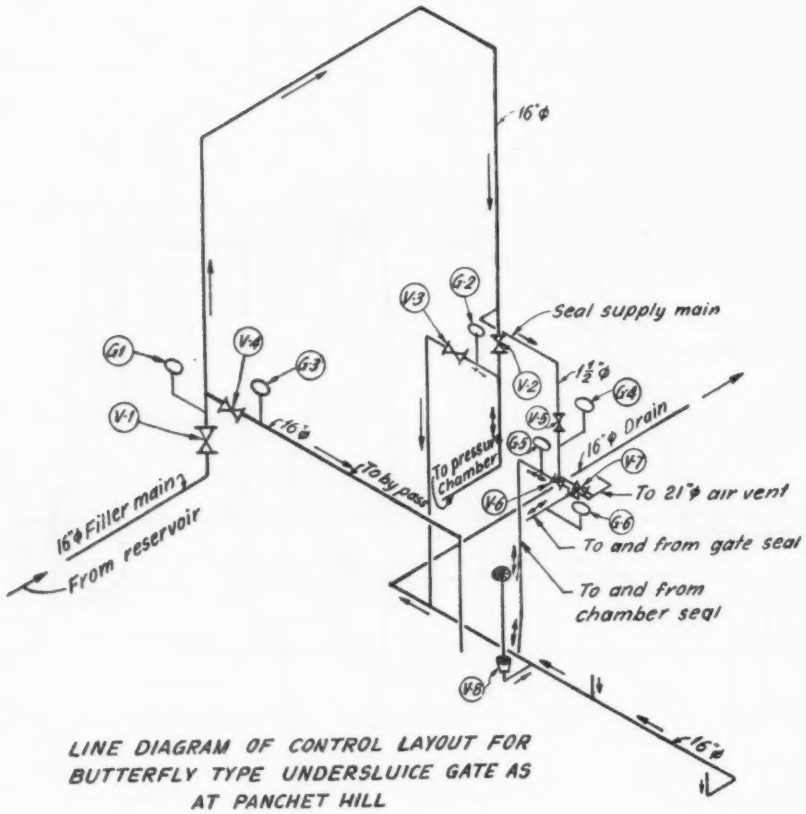
Gate in open position.

SKETCH II



Gate in closed position.

SKETCH III



LINE DIAGRAM OF CONTROL LAYOUT FOR BUTTERFLY TYPE UNDERSLUICE GATE AS AT PANCHET HILL

LEGEND :-

V-1 ... Valve no.1 - 16"ϕ main valve.
V2 .... Valve no.2 - 16"ϕ filler valve.
V3 .... Valve no.3 - 16"ϕ drain valve.
V4 .... Valve no.4 - 16"ϕ by pass valve.
V 5 .... Valve no. 5 - 1½"ϕ seal main valve
V-6 .... Valve no.6 - ¾"ϕ threeway valve
V-7 .... Valve no.7 - 1½"ϕ threeway valve.
V-8 ... Valve no.8 - 6"ϕ plug drain valve.
G1 .... Gauge no.1 - filler main pressure gauge
G2 .. Gauge no.2 - chamber pressure gauge.
G3 Gauge no.3 - bypass pressure gauge
G4 .... Gauge no.4 - seal main pressure gauge
G5 .... Gauge no. 5 - chamber seal pressure gauge.
G6 .... Gauge no.6 - gate seal pressure gauge.

SKETCH IV

Gate Cover:—This consists of a rectangular welded plate frame with the lower half contoured to fit the opening in the embedded steel plate liner. The cover is designed to take full high headwater pressure at all times as well as horizontal thrust due to the gate load at the top bearing. The top bearing box is incorporated with the cover.

When the cover is in place it is decked over with steel grating. The top of the grating when in place is flush with the finish floor of the gallery with no protruding parts above, so much so an unobstructed continuous floor in the gallery is obtained.

The inter-spaces between the gate cover and gate liner are filled with unbonding non-shrink grout all around to prevent any ingress of water into the cover. With plain faces of the gate cover and the top liner, a difficulty might be experienced in the removal of the gate cover when desired. This can be overcome by slightly inclining the sides of the cover and of the top liner neck so that the grout instead of filling a vertical space will fill a space that slopes outwards from the bottom up. The surfaces that are in contact with the grout are carefully treated to prevent bond. With the cover and the liner beveled in this manner, when the cover is to be removed, the clearances between the cover and the liner will increase as the cover is raised, thus permitting easy removal.

Head water supply and drains:—For the Panchet Hill gate, the head water supply line is a 16″ pipe extending from the upstream face of the dam to the point near the gallery wall. A suction strainer at the upstream end will keep off any fish and debris from entering the supply line. As soon as this pipe enters the gallery, it is branched into two, with control valves in each branch, to act as filler lines for the upstream and downstream compartments of each gate. A two inch air vent is provided into the gate pressure chamber to relieve any tendency of creating a vacuum when the pressure chamber is draining.

GATE OPERATION

As has already been stated, the gate is operated by utilising the reservoir water pressure. The liners and the sluice gate are all below the floor of the operating gallery of the dam and all that the gate operator is to acquaint himself with for the opening and closing of the gate is the manipulation of a few sluice valves in the operating gallery. Sketch No. 4 shows the line diagram of control layout for this gate (the view is isometric). By a reference to sketches No. 1 and No. 4, it may be seen that there is a main pipe line, called the filler main, leading from the reservoir to the so-called pressure chamber of the gate. There is also another main pipe line, called the discharge main, leading from the pressure chamber to the downstream end of the dam. The flow of water in these pipes is controlled by means of sluice valves suitably located in the line in the operating gallery so as to be easily accessible to the operator. It may be noted from sketch No. 4 that there are in all eight sluice valves for the whole system.

Gate in the open position:—Sketch No. 1 shows the general arrangement of the gate, when in the open position. In this position, contact is established between the reservoir and the gate pressure chamber by opening the filler valve of the pipe system. It is thus apparent that the water pressure acting on either side of the longer arm of the gate leaf is the same and thus gets neutralised when the water is flowing through the undersluice; and so the only effective pressure is the one being exerted on the shorter arm of the gate leaf. Thus the gate leaf remains in the open position. In this position of the gate leaf, it is only the chamber seal (Sketch No. 2) that is inflated under pressure and the other seals need not be under pressure, as any leakage through these seals will not affect the open position of the gate in anyway.

To close the gate:—The contact between the reservoir and the pressure chamber is cut off by shutting the sluice valve in the filler main. The result of this is that the pressure chamber now contains a volume of water which is not under any external pressure, and thus as soon as the main discharge valve is opened, this pocket of water immediately finds its way out into the discharge pipe. This is because, as the water is flowing in the conduit, reservoir water pressure is being exerted on both arms of the gate leaf and the total pressure on the longer arm being naturally more, the gate swings in a direction against the flow of water. Gate stops are provided to prevent any further movement of the gate leaf when it has reached the closed position. In this position it is very important to keep all the rubber seals under pressure so as to prevent any leakage of the water into the pressure chamber.

To open the gate:—The pressure on the gate seals is first released, the drain valve closed and the filler valve opened. The gate then opens out itself. This, in general, is the operating procedure for this gate. The gate is provided with all requisite manifold such as manhole drain pipes, vacuum breaking vent pipes etc., whenever required.

Sketches 2 and 3 have been incorporated to show in greater detail the gate in the open and closed positions.

Theoretically speaking, the opening and closing of the gate should be possible instantaneously, the only time required being for filling the water into the pressure chamber or draining the same from the pressure chamber. However, for achieving a smooth operation, the valves are so operated that the gate movement is effected in about 20 seconds.

The operation procedure of the gate is more concisely illustrated below in reference to sketch No. 4 attached.

(Continued on page 58)

Selection of Earth-moving Equipment

By S. S. PILLAI
formerly Superintending Engineer, Construction Plant Circle, DVC

CONSTRUCTION with the aid of mechanical equipment has come into vogue in recent years. Economy and speed are the essential factors in the use of mechanical equipment for construction. The whole outlook of mechanical construction is based on the advent particularly of the commercially successful high speed Diesel Oil Engine and on the evaluation of various track link devices. In recent years the Ward-Leonard control system of operation has come into use. This system provides maximum current at low voltage, thus giving high torque at low speed and low torque at high speed and has very low maintenance cost. This system is being used now on large excavators and draglines.

PLANNING

Planning and programming the various construction procedures and equipment are basic needs of modern construction. Improvement in designs of equipment to suit varied conditions and purposes has extended the scope of such work making it possible to undertake any construction by mechanical means. In large-scale construction, it is imperative that suitable and most efficient types of equipment are selected for different works to obtain the maximum efficiency and output. This depends on working conditions, materials to be handled, arrangements for disposal of excavated materials, haulage distances borrow areas, blasting facilities etc. Each project has to have special data as all the printed data available can only be considered as averages.

PRINCIPLES OF SELECTION

These principles apply to the selection of used equipment also as consideration has to be given for the residual value of equipment. Particularly in this country where manufacture of heavy equipment has not yet commenced and as there is acute shortage of skilled men for operation and repairs, it is far from advisable to begin any project with only used equipment. The various aspects to be considered in the selection of equipment, therefore, are the sizes and standards of equipment as well as other factors mentioned below. However, a mixture of used and new equipment would be of advantage, in the right proportion.

(A) *General*

(i) The cost of ownership, depreciation, maintenance and operation.

(ii) The cost of hauling equipment and their running costs.

(iii) Capacity of loading and hauling equipment with reference to grades, traction, local conditions, materials to be handled and other field conditions.

(iv) Hauling distance and time cycle including loading, hauling, dumping and return.

(v) Capacity of loading equipment with reference to hauling equipment.

(vi) Allowance for loss in operational hours due to poor maintenance, inexperienced personnel etc.

(vii) Comparison of loose and bank measurements.

(viii) Varying capacities and efficiency of different equipment.

(B) *Performance*

(i) Tractor bulldozers are the cheapest equipment for pushing loose and soft or semi-hard earth from banks to a maximum of about 250 ft. as also for grading and levelling .

(ii) Tractor scrapers are cheapest for cutting, self-loading and spreading of earth between distances of 150 ft. and 600 ft.

(iii) Power scrapers are cheapest for cutting, loading, hauling and spreading over 500 ft.

(iv) The smaller tractor units are less economical than the larger but slower units, except for short hauls.

(v) On short hauls, scrapers are cheaper than elevating graders.

(vi) Shovels are cheaper and more efficient on hard soil and blasted rock and shale with hauling equipment.

(vii) Draglines are cheapest on excavation of large depths and side casting, if the right capacities are used.

Other aspects to be considered in the selection of equipment are the sizes and standards of equipment. Smaller jobs must almost always depend on smaller and standard equipment. This will save capital costs and maintain efficiency and uniformity in output. As far as practicable, similar types of equipment with multi-purpose duties are to be preferred on all jobs and this will facilitate maintenance, supply of spares, etc. Suitable selection of equipment has also to be based on a balanced running of excavating and hauling equipment with due consideration being given to hourly output of individual equipment as excavating equipment seldom gives the maximum efficiency due to varying factors.

REVIEW OF EQUIPMENT

A survey of different types of earth-moving equipment with their uses and history in brief may be of value for the selection of equipment.

Crawler Tractors and Scrapers

This is a prime moving equipment used for moving units of bulldozers, scrapers, wagon, etc., especially for rough roads, their speeds varying on the basis of horse power between 1.5 and 9 miles per hour. They are also used for agricultural operations. When they are used with bull-dozers, they are best suited for pushing, levelling and grading earth downhill as well as for angle dozing. As bulldozers, they can handle earth economically up to 250 ft. haul, depending on the capacity.

With the advent of fast-moving pneumatic tyred equipment in recent years, it has been found that the tournadozers on tyres are more economical as far as loose earth has to be dozed to a distance between 200 and 400 ft.

Tractors are used with scrapers for cutting, loading and hauling earth to long distances where it is impractical and uneconomical to get this done by bulldozers. The economic distance to which hauling by tractor-scrapers can be effected is between 150 and 600 ft.

There are various makes of tractor-drawn-scrapers and bulldozers today, called Caterpillar, Birtley, Bucyrus-Erie, Onion Ruston Bucyrus, Isaccsons, etc., and they are being extensively used. Caterpillars, International Harvester, Allis-Chalmers, Oliver, Fowler, Marshalls, Vickers, Ansaldo, etc., are some of the many tractors in the field today. The bulldozers are of two kinds, hydraulically operated and cable operated.

For Indian conditions, where dusty conditions are bad and maintenance is poor and skilled personnel are few, cable operated bulldozers would be preferable. Considerable trouble experienced in hydraulic rams, breakage of hoses, etc., can thus be obviated, although hydraulic equipment is easier for operation.

The scrapers normally are operated by power take-off from crawler tractors. They are of varying capacities suitable for different types of tractors of varying draw-bar horse power capacities.

Rooters are equipment with three or five prongs to penetrate into the ground and drawn by crawler tractors. These are meant to assist bulldozers and scrapers as auxiliary equipment when they have to cut stiff clay or hard surface.

Power Scrapers

In the same way as we have tournadozers, power scrapers have also come into use. They are comparable with crawler tractor-scrapers only as regards the purpose of cutting, loading and hauling and spreading, but are normally filled by push loading by crawler-tractors and they run on pneumatic tyres. The crawler tractor and scraper have an average speed of 1.5 to 5 miles per hour at the maximum, whereas the power scrapers vary in speed from 15 to 25 miles per hour with full load. The other difference is that for loading a few power scrapers, a crawler tractor is required.

OUTPUT OF BULLDOZERS

Tractor type	Drawbar horse power	Nature of ground and length of push in feet and output cu. yds. per hour							
		Sand		Soil		Stiff clay		Brocken rock	
		100 Feet lead	200 Feet lead	100 Feet lead	200 Feet lead	100 Feet lead	200 Feet lead	100 Feet lead	200 Feet lead
D4-TD- 6 & HD 5	35 to 45	25	14	20	11	10	6	13	7
D7-TD-18 & HD 15	80 to 110	60	10	48	24	24	12	30	15
D8-TD-24 & HD 20	140 to 180	77	18	62	30	31	15	39	19

EXCAVATION BY TRACTORS AND SCRAPERS

Type of tractor and scraper	*Rated capacity*		Nature of ground and length of haul (one way) in lin. yds. plant hours per cu. yd.							
			Sand		Softy clay		Stiff clay		Soft rock	
	Heaped cu. yds.	Struck cu. yds.	200 Feet lead	400 Feet lead	200 Feet lead	400 Feet lead	200 Feet lead	400 Feet lead	200 Feet lead	400 Feet lead
D7-TD-18 & HD-15 tractor & No. 70 scraper	9·5	7·2	0·022	0·032	0·029	0·033	0·033	0·048	0·088	0·128
D8-TD-24 & HD-20 tractor & No. 80 Scraper	14·0	11·0	0·015	0·022	0·020	0·029	0·023	0·033	0·060	0·088

The increase in cost by the use of pushers, which are themselves based on distances of haulage, is compensated by the speed of operation. The normal average-sized power scraper of 14 cu. yd. capacity does not cost much more than a 180 h.p. tractor and 15 cu. yd. scraper and, therefore, the cost is cheaper, particularly for long distances. The earth being soft or medium soft, this operation carried out by power scrapers is even cheaper than shovel-cum-hauling dumper operation. One important difference between power scrapers and tractor scrapers is that the latter can be used even in very wet ground conditions whereas the others cannot be used under such conditions.

One of the principal factors contributing to the rapid development of power-scrapers is the introduction of heavy-duty rubber tyres of exceptionally large sizes capable of withstanding arduous construction service. These tyres are not only capable of coping with speed but can also travel over soft ground due to their large bearing surface and their rolling resistance is reduced under most conditions.

The capacities of these scrapers are from 6 to 28 cu. yds. and increases in output are effected at reduced costs. The latest types of power scrapers are the Le-Tourneau Westinghouse 'D', 'C' and 'B' Roadster Tournapulls, Super-C-Tournapulls, Allischalmer TS-360 Scrapers, Wooldridge Terra-Cobra Scrapers, Blaw-knox Goliath Power-Scrapers, etc., with horse power ranges of 100 to 300 on different equipment.

Graders & Elevating Graders

These are auxiliary equipment but with prime movers and are used mainly for road making, grading and maintaining haul roads for dumpers.

The elevating graders consist of a tractor drawn steel frame which has a blade to cut the earth and deflect it on to a short section of belt conveyer. In recent years substantial improvements have been made and the modern units are capable of loading 300-800 cu. yd. per hour.

The factors which require consideration in the selection of graders are their output, nature of soil to be handled, soil consistency, its freedom from stumps, power and speed of pull tractor, dimensions of borrow areas to allow for turns, numbers of hauling units and clearance under the conveyer arm to allow rapid flow of material.

On larger jobs it is advisable to use the power unit on the elevating graders itself whereas on the smaller jobs it is common to operate the belt on the grader by means of a power take-off from the tractor which pulls the grader.

Dumpers

These are hauling units of varying sizes from 2 to 28 c.yds capacity. The suitability of these equipment is based entirely on the loading capacities of loading equipment such as shovels, elevating graders, draglines, etc., and on the distance to be hauled.

There are various models in the market today such as the Muir-Hill, Aveling Barford, Euclid, Mack, Tourna-Trailers, Tourna Rocker, etc.

Very good roads are required for the satisfactory running of these equipment and maintenance costs could be kept down by good maintenance of roads although this expenditure may appear high.

Power Shovels

These are best suited for close range work. They have good control over digging and have good speed. Determination of suitable sizes depends entirely on job conditions and it is very important to select shovels to suit the capacity of hauling units and vice versa. Care has to be taken not to obtain too big a shovel for maximum output as it would be a very heavy expenditure when there is no work.

SHOVEL, DRAGLINE/AND CLAMSHELL OPERATION

(CYCLE TIME AND MAXIMUM OUTPUT)

Classes of Material	Coefficient		
	Shovel	Dragline	Clamshell
Light, Moist, Clay or Loam which heaps upon bucket or dipper	1·00 — 1·15	1·00 — 1·15	1·00
Ordinary earth or loose sand & gravel	0·80 — 0·90	0·80 — 0·90	0·80
Light clay mixed with gravel	0·65 — 0·75	0·65 — 0·75	0·50
Heavy clay and boulders	0·50 — 0·65	0·45 — 0·65	0·40
Blasted rock hardpan or tough rubbery clay	0·35 — 0·45	0·30 — 0·40	0·20

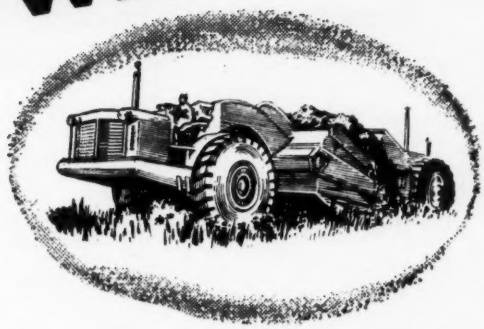
Details, such as short or long shovel booms, ball or roller bearings or plain bronze bearings, use of ordinary metals where special alloys would add greatly to life or open gears in the place of cut gears fully enclosed and running in oil have a decided effect on equipment performance although these details are not normally observed.

Similar details go into the selection of engines and it is not necessary to obtain equipment with engines supplied with them. Horse power bare and with auxiliaries, maximum speed and torque of the machine are also to be considered. A high horse power at high speed is of less practical value in shovel design although the bigger horse power sounds important and assists quicker sale of equipment. One of the chief advantages of a modern shovel is its convertibility into dragline, clamshell, crane, scoop or ditcher although some shovels are not so well equipped as others. Shovels today have a range of 3/8 to 60 cu. yds. bucket capacity.

EUCLID SCRAPERS CLEAR THE WAY

Euclid S-7. 7 yds. struck capacity. 143 h.p. Lever action of bowl, apron and ejector.

Euclid S-18. 336 h.p. engine with Torqmatic Drive. 21 yds. struck capacity. Planetary Drive Axle with NoSpin Differential.



Euclid TS-24. Twin Power Scraper. Two diesel engines give total of 563 h.p. Struck capacity 24 yds. The big Scraper for the big job.

A Scraper for every job—that is the proud claim of Euclid. Ranging in struck capacity from 7 cu. yds., to 24 cu. yds., Euclid Scrapers are clearing the way and helping to lay the foundations on which the new Industrial India is being built.

Euclid Scrapers for all round performance cannot be beaten. They cut and transport more dirt faster at cost-trimming figures than any similar equipment at present in use.

A record of steady production, with every trip a maximum pay – load has made Euclid Scrapers the first choice of construction men the world over.

BH BLACKWOOD HODGE

Assisting the Second Five-Year Plan

BLACKWOOD HODGE

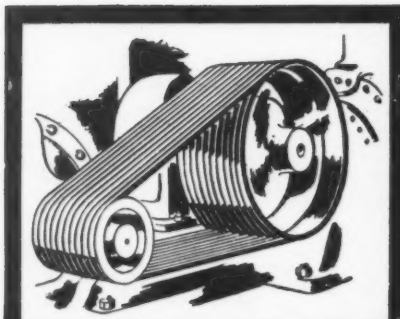
BLACKWOOD HODGE (INDIA) PRIVATE LTD.

Associated Companies, Branches, Works and Agencies throughout the World.

EUCLID

GC/79

GET THE MOST FROM YOUR HORSE-POWER WITH GOODYEAR BELTING

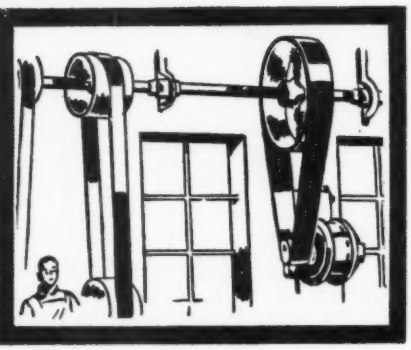


Modern heavy duty drives demand belts of outstanding strength and flexibility. Each belt is part of a team prepared to withstand impossible strains in load and shock, meeting them with a high degree of balance and drive force.

GOODYEAR RAYON V-BELTS
FOR HEAVY DUTY DRIVES

GOODYEAR TRANSMISSION BELTING
FOR POWER ECONOMY

Slippage, stretch and frequent adjustments of belts can cause loss in power and output. Goodyear Transmission belts are built to suit the specific job, grip better and last longer.



GOODYEAR

THE GREATEST NAME IN RUBBER

PSIP-11

BUY TB SEALS AND HELP FIGHT TUBERCULOSIS

In this connection a brief history of the development of shovels may perhaps be of interest. Up to 1895 all the ironstones in the U.K. were obtained by means of hand labour, the deposits being picked usually from one end of the outcrop after removing the cover. The cover was also removed by means of hand labour and wheel barrows to dumps. The overall cost of loading and transporting was very cheap, amounting to two to three annas per cubic yard. In some instances it also included removal of top soil and sub-soil and levelling the ground after the removal of the ironstone.

In 1896, Messrs Stewart & Lloyds installed a shovel of 1½ cu. yd. bucket capacity and used it for stripping overburden. Overburden was then transported by belt conveyer to dumps. In 1900 they used a long-boomed shovel for stripping which enabled them to increase output and reduce expenditure. The weight of this shovel was 70 tons with 70 ft. boom, 60 ft. dumping radius and 1½ cu. yd. capacity. This was the first long-boomed stripping shovel constructed.

The next move was made in 1904 by Davis of Egarton who installed in his quarries a 12-ton steam shovel with a bucket capacity of 1½ cu. yd., working in conjunction with a skip type conveyer, the advantage of the skip over the belt being that the dumping can be made at a desired point. In 1904, Davis installed a large steam shovel, 70-75 tons in weight with a 3½ cu. yd. bucket, which proved to be the forerunner of large and heavier machines.

In 1905 Messrs Lord St. Oswalds Iron-stone Co., now Messrs Frodingham Ironstone Mines Ltd., installed a small German Lu-becker combination of bucket excavator and belt conveyer for removing overburden consisting mainly of sand. This machine worked successfully for many years until 1917 when Messrs Henry Barry & Co., Leeds, built a larger machine of the same type. This machine is still in service having been reconditioned in 1942. Messrs Taylor & Hubbart of Leicester built another machine in 1930 with a conveyer 130 ft. long and working depth of 60 ft. and a total weight of 130 tons. This was used by Messrs Frodingham & Co. Ltd. on ranges above and below the working level of the machine.

Draglines

The dragline is one of the most flexible modern excavating equipment which has a longer reach than a shovel both for excavation as well as for disposal. It can dig far below its base as well as in any other direction and can excavate under water. It is not hampered very much by weather and has an easier freedom of locating and loading hauling equipment.

Whereas a dragline has all the above advantages, its serious disadvantage is that it cannot handle hard excavation as efficiently as a shovel. The average rate

EARTH MOVING BY ANGLE DOZER

Type of tractor	Nature of ground and plant hours per sq. yd.			
	Sand	Broken Rock	Loamy soil soft and sandy clay	Stiff clay
	LEVEL			
D4, TD 6 & HD 5	0·017	0·043	0·023	0·046
D7, TD 18 & HD 15	0.010	0.025	0.027	0·027
D8, TD 24 & HD 20	0·008	0·020	0·022	0·022
	1 IN 7 UP			
D4, TD 6 & HD 5	0·028	0·070	0·037	0·076
D7, TD 18 & HD 15	0·016	0·040	0·043	0·043
D8, TD 24 & HD 20	0·013	0·033	0·035	0·035
	1 IN 7 DOWN			
D4, TD 6 & HD 5	0·013	0·033	0·017	0·035
D7, TD 18 & HD 15	0·008	0·020	0·022	0·022
D8, TD 24 & HD 19	0·006	0·015	0·016	0·016

of dragline output is about 80 per cent of the shovel output due to greater angle of turns and longer time taken for dumping and disposal due to long booms. The main purpose of a dragline is long reach and, therefore, the time for each cycle of operation is longer.

Depth of refilling and ramming trenches per cu. yard.
MECHANICAL EXCAVATING PLANT OF THE ENDLESS BUCKET TYPE

Date of Trench in feet	Nature of ground and plant hours excavating refilling and ramming trenches per cu. yards.			
	Firm sand	Soft soil, Softy or sandy clay	Gravel	Stiff clay
	Plant hours	Plant hours	Plant hours	Plant hours
1	0·068	0·096	0·102	0·116
2	0·064	0·090	0·096	0·109
3	0.060	0·084	0·090	0·102
4	0·056	0·078	0·084	0·095
5	0·052	0·073	0·078	0·089
6	0·049	0·069	0·074	0·084
7	0·047	0·066	0·070	0·080
8	0·049	0·069	0·074	0·084
9	0·052	0·073	0·078	0·089
10	0·056	0·078	0·084	0·095
11	0·060	0·084	0·090	0·102
12	0·064	0·090	0·096	0·109

Boom lengths are variable with reference to bucket capacity and the shorter the boom the larger can be the bucket. The usual angle at which the boom is set varies between 30° and 40°.

As in the case of shovel buckets, maximum care

has to be taken in selecting a dragline bucket. This has to be done with particular reference to the type of material to be handled, the same as selecting a suitable cutting tool. The combination of width, balance and height of bucket and number, angle and location of teeth with respect to dragline yoke, and the relation between length of boom and overall capacity of bucket, all affect the output of the machine in different materials. The extra cost incurred in obtaining a suitably designed bucket is quickly covered by increased output. Easy digging often warrants the use of oversize buckets, such as the excavation of sand. This usually necessitates a higher boom angle.

In this country it is very difficult to follow all these methods very much due to supply difficulties and due to the fact that all equipment need to be imported. Owing to the urgency of jobs and financial problems normally experienced in Government projects, the above practical and theoretical considerations are very often overlooked or disregarded.

The question of swell factor of material handled is of special importance. This percentage varies with the material concerned and the type of equipment used.

CONCLUSION

These give only a general idea of the basic needs for selection of equipment for particular types of jobs. Without adequate construction experience by those responsible for selection of equipment these will not by themselves be of advantage. The construction Chief must have adequate experience in the use of various types of equipment under varying conditions of climate, soil and working conditions.

Mention has not been made here about the larger sizes of equipment in general. There are several equipment such as the Caterpillar D-9 Tractor with attachments, Allis-Chalmer HD-21 Tractor, Euclid Twin-engined Power Scraper, large Marion Shovel of 60 cu. yds. capacity and 30 cu. yds. capacity Ransome-Rapier Walking Dragline with 282 ft. boom. All these have come into use now and the development of equipment has been proceeding at a very rapid pace. This is closely linked with mining of iron ore, as well as opencut mining. The development of such equipment is so rapid that the amount of work involved has to be so large to justify any large scale purchase of heavy equipment. It is time, therefore, that India also starts manufacture of heavy equipment simultaneously with development as recommended by the Rates and Costs Committee.

MODIFIED BUTTERFLY TYPE UNDERSLUICE GATE, AS ADOPTED IN TWO OF THE DVC DAMS

(Continued from page 53)

TO OPEN THE GATE

1. Valve No. 1 is normally open; if not, open it.
2. Valve No. 4 is normally closed; if not, close it.
3. Close valve No. 5.
4. Release seal pressure by operating valve Nos. 6 & 7, draining the seal lines to the air vent. Gauge Nos. 5 & 6 should indicate zero perssure.
5. Close valve No. 3.
6. Open valve No. 2 slowly in such a way that the gate opens in a period of not less than 20 seconds. Gauge No. 2 should indicate reservoir pressure when the gate is fully open.

TO CLOSE THE GATE

1. Close valve No. 2.
2. Open valve No. 3 slowly in such a way that the gate will be closed in a period of not less than 20 seconds.
   Gauge No. 2 should indicate zero pressure when the gate is fully closed.
3. Open valve No. 5.
4. Develop seal pressure by operating valve Nos. 6 & 7. Gauge Nos. 4, 5 & 6 should indicate reservoir pressure.

Note: Valve No. 8 comes into service when an inspection of the gate is called for, as mentioned below.

INSPECTION OF THE GATE

When the gate is fully closed, the downstream compartments can be entered. A mandoor has been provided on each side of the steel liner so that it is possible to enter on each side of the vertical fixed seal, called the chamber seal. In this manner it is possible to inspect the gate seals as well as the downstream face of the gate and liners. Before entering the pressure chamber the plug drain valve (valve No. 8) must be opened to completely drain this chamber.

The compartment upstream of the Butterfly gate can be entered into by first lowering the sluice emergency gate into position, thus closing the undersluice opening. When the emergency gate is in place, the Butterfly gate is opened as described above which will drain the upstream compartment. When the compartment has been drained, the mandoor just upstream of the gate cover in the dam operating gallery is opened and the compartment entered. In this way the gate and the seals can be inspected in their place. In case of any major repairs, the gate leaf can be taken out of the gallery, repairs attended to and the gate installed into position again.

CONCLUSION

This novel device for the regulation of flow in the dam sluices is adopted for the first time in the world in this country in the DVC projects. It is hoped that this wll come to stay and hold the ground for the time to come on account of its simplicity in fabrication and operation over the existing arrangements.

Drilling and Grouting in the Underground Power House at Maithon

by A. C. DAS GUPTA, B.E.,
Executive Engineer, DVC.
and
M. L. SUBBA RAO, B.E.,
Assistant Engineer, DVC.

MAITHON Project is one of the important multi-purpose projects constructed by the Damodar Valley Corporation in the first phase of development. The main features of the Project consist of an Earth Dam across the River Barakar, with a concrete spill-way across the Diversion Channel on the right bank and an underground power house with an installed capacity of 60,000 kVA on the left bank. The under-ground power house comprising of a main hall for generators, (three Nos.) vaults for location of turbines and their scroll cases (three Nos.) penstock tunnels, access tunnel, ventilation and emergency shaft, tail race tunnels and surge chamber etc. had to be hewn out of rock in the bowels of the left bank hills.

This meant considerable quantity of tunnelling and underground excavation. The rock strata though, found to be quite suitable for tunnelling required some consolidation and stabilisation, particularly on account of blasting operations, in order to guard against the seepage of water from the reservoir and the consequent risk of flooding the Power House. To achieve these objects extensive drilling and grouting operations were undertaken both before and after the excavation works.

EQUIPMENTS USED

For drilling deep grout holes both pneumatic and electrical diamond drills were employed with $1\frac{7}{8}''$ diamond bits and core barrels from 2′ to 10′. Pneumatic drifters mounted on stagings were used for drilling shallow holes upto 30 ft. The holes were 2 ins. in diameter. The equipments used for pressure grouting consisted of grout pumps, grout mixers, agitator sumps, pressure gauges, pipe lines etc. The grout pumps used were of two types, one was of the duplex reciprocating type operated by compressed air. This could pump-in grout at pressures more than 200 lbs. sq. inch. The other one was a hand grouting pump which consisted of a grout mixer and a cylinder with a piston worked by a lever and a ball valve. This was operated by manual labour and the machine proved to be rugged, compact and very handy for low pressure grouting upto 50 lbs. per sq. inch, and where only small quantities of grout were involved. During its service here, only the piston had to be replaced. This was manufactured at the Mechanical Workshop at Maithon itself.

Both varieties of the grout pumps required frequent replacement of the gland packings as cement was found to render these packings useless too frequently. It was also observed that certain hard particles in cement like preset lumps etc. were not only wearing out the machines but also choking up the pipes. Hence the cement was, throughout the grouting operations, passed through a sieve before feeding the mixer. As soon as the grouting work was stopped, the whole system including the pumps and pipe lines were flushed with clear water to remove all cement particles. This ensured a trouble-free operation and long life for the equipments.

The grout mixers and agitators used were both of the air motor operated and manually operated types. These consisted essentially of a cylindrical tank with agitator blades fixed to a vertical stem which was connected either by a pulley to an air motor mounted on a bracket or by a gear and pinion arrangement to a horizontal handle for manual operation. An agitator sump was used to provide a continuous feed to the pumps. This was located either below or by the side of the grout mixer

Pressure gauges callibrated in pounds per square-inch were used for controlling and regulating grout pressures. They were fitted with diaphragm gauge/savers which prevented grout from entering and corroding the inside of the gauge.

GROUTING PROCEDURE

As soon as a hole was drilled a $1\frac{1}{2}''$ G.I. or M.S. pipe length with a nipple at the outer end would be pushed into the hole and packed with lead wool or cement grout. Then a bypass valve and a pressure gauge were fitted to the nipple. A hose pipe carrying grout was then connected to the pressure gauge.

In the circulating system, which was adopted for the pneumatic duplex reciprocating grout pumps, the bypass valve was connected by a return pipe to the grout mixer (see Fig. 2) whereas in the single line system which was generally used for the hand operated grout pump, the bypass valve was allowed to discharge into the air near the hole itself (see Fig. 3). Before any grouting operation was started, the hole was thoroughly washed with water under pressure to wash out any clay or other washable materials out of

intersected rock seams and crevices. Pressure testing was then done to determine the consistency of grout mixture to be pumped in. In this process clean water was forced under continuous pressure, a little lower than the maximum pressure under which grouting was to be done, and the rate of loss of water was observed to get an idea of the tightness of the holes. If the pressure test indicated a tight hole, grouting was started with a thin mix of the order of 9 parts by volume of water to 1 of cement. It was found convenient to measure water and cement by volume. When an open hole condition was observed as determined by the rate of loss of water or inability to build up pressure during water testing, the grouting was begun with a thicker mix with the grout pump operating as nearly as possible at constant speeds at all times. The mix was gradually thickened until the desired pressure was reached. When the pressure tended to rise too high the water cement ratio was increased and vice versa. Grout mixes up to 4 parts of water to 5 parts of cement were used. The rate of pumping, water to cement proportion etc. were carefully decided taking into consideration, the actual condition at site, and information gathered from loss of drilling water, water test results etc. The grouting of any hole was not considered complete until the hole failed to take grout at the rate of less than 1 cft. of grout mixture in 20 minutes when pressures of 50 lbs. or less were used, in 15 minutes when pressures between 50 and 100 psi were used and in 10 mins. when pressures above 100 psi were used. After the grouting was completed the pressure was maintained by means of a stop cock or other suitable device until the grout was set to the extent that it would be retained in the hole.

CLASSES OF GROUTING DONE

The grouting works done for the Power House may be classified as follows depending upon the purpose for which they were done.

1. Curtain grouting to provide a vertical impervious curtain of cement grout between Power House and the Reservoir.
2. Blanket grouting to provide an impervious cover over the roof of the main hall.
3. Consolidation grouting for stabilising the rock zone around the main hall of the Power House.
4. Back fill grouting for filling up cavities and crevices, which could not otherwise be filled up by concrete on account of inaccessibility of the location as in penstock lining, diversion tunnel plug, scrolls case filling etc.

CURTAIN GROUTING

The Power House and its various components, by virtue of being located underground were to be blasted and excavated out of the depths of the left bank hill. The excavations had to be done at levels below the bed of the river. To eliminate any seepage and risk of flooding during construction period, it was decided to cut off the Power House area from the reservoir by a curtain of grout along the upstream side. 25 Nos. of holes were drilled up to depths of nearly 280′ extending below the floor of the Power House (See Fig. 4). Ax $1\frac{7}{8}$″ diamond bits were used for drilling. Through the overburden portion a 3″ hole was drilled by 3″ Nx carbide bit and a casing pipe 2″ in diameter was pushed in and jammed into each hole with lead wool or cement grout. This casing pipe was long enough to extend up to rocky zone. Grout mixture of neat cement and water was injected with a pneumatic duplex pump through this pipe after thorough washing of the hole. Prior to grouting the holes were water tested under pressure to determine the loss of water, according to which the proportion of cement to water was fixed up. The maximum pressure under which grout was to be pumped in was 200 lbs/sq. in.

The spacing of the grout holes were as originally proposed, to be determined by the split splicing method in which the interval between the grout holes is progressively reduced by drilling and grouting intermediate holes until satisfactory tightness is obtained in the rock formation. But in the case of this curtain grouting, it was found that only a comparatively less quantity of grout was sufficient to seal off the holes, even under maximum pressure. Also while drilling much water loss was not observed. Hence it was decided that no intermediate holes were necessary. The initial curtain grouting was considered to have been quite effective since leakage water encountered during construction period was not excessive.

After the excavation work of the Power House was completed, it was assumed that the rock zone immediately surrounding the Power House would be disturbed due to the heavy blasting done during the construction period. This was substantiated by seepage observed through the rock surfaces. Since it was absolutely essential that the seepage be reduced to the barest minimum and that disturbed rock be stabilised, it was decided to have a final curtain of grout just upstream of the Power House, a grout blanket extending over the roof of the main hall, and extensive shallow grouting through the walls. Nineteen holes were diamond drilled 9 feet apart extending from the ground surface right upto 10′ above the Power House. The procedure of drilling and grouting was the same as that of the initial curtain grouting, except that the multistage method was adopted for grouting. As the drilling of the holes was continued, the loss of cooling water was observed. Whenever the loss was found to be excessive, indicating existence of cavities or fissures, the holes were grouted and redrilled after the cement had set. This was repeated until the final depth was reached. In some holes, intermediate layers of pebbles and stone dust were encountered. Through these layers the diamond drill

bits were either wearing out very soon or were drilling no further. In such cases also, although water loss was not observed during the holes were grouted and re-drilled, in one of the holes pressure was not being developed although a good amount of cement had been pumped in. Then it was discovered that the grout was making its way through a fissure into the reservoir. The proportion of cement to water was raised to 5:4. Still when the leakage did not decrease, equal parts of fine saw dust was added to cement and the grout pumped in. Addition of little amounts of alum hastened the setting of cement. This stopped the leakage and the hole was grouted to full pressure. The tables 1 & 2 show the particulars of the drilling and grouting of each hole of the initial and final curtain groutings. From these it may be seen that an appreciable quantity of cement has been consumed in the final curtain grouting also as compared to the first curtain grouting. This fact is a further proof of the assumption of the disturbance of rock upon which the final curtain grouting was decided.

BLANKET GROUTING

For the removal of blasted muck from the Power House a vertical mucking shaft was driven from the ground surface to the area of excavation. Later, after the arch roof concreting and the excavation work was completed, grouting was done under low pressure through holes diamond drilled through concrete radiating from the mucking shaft so as to provide a blanket of grout over the roof of the Power House as shown in the Fig. 4. Further seven holes were drilled through the concrete plug of the mucking shaft and were grouted to stop the seepage through the contact surfaces of the plug. The grouting was done by means of the pneumatic duplex grouting machine. The particulars of holes drilled and grouted are as per table Nos. 3 & 4.

CONSOLIDATION GROUTING

As described earlier, to consolidate the disturbed rock around the Power House and to reduce the seepage water to a minimum the walls of the Power

TABLE NO. 1

FIRST CURTAIN GROUTING

Sl. No.	Depth of Hole Rft.	Depth of over burden Rft.	Nature of core	WATER TEST		Cement pumped Cft.	CEMENT : WATER (by volume)			Max. pressure p.s.i.	Time of grouting hours.
				Loss g.p.m.	Pressure p.s.i.		Initial	Final	Average		
1	2	3	4	5	6	7	8	9	10	11	12
1.	264′6″	31′	WR,G	18	170	208	1:9	1:3	1:6	200	23
2.	261′8″	37′	WR,G	15	180	151	1:9	1:3	1:6.5	200	17
3.	257′9″	68′9″	WR,G	12	180	88	1:9	1:8	1:8.5	200	18
4.	250′6″	54′	G,SR	10	180	2	1:9	1:9	1:9	200	1
5.	243′7″	15′8″	G,SR	25	200	123	1:9	1:3	1:6	200	24
6.	234′9″	54′	G,SR	18	200	43	1:9	1:8	1:9	200	8
7.	227′	56′4″	SR,Do	24	200	3	1:9	1:9	1:9	200	1
8.	219′5″	36′2″	Do,G	14	200	1.5	1:9	1:9	1:9	200	1/3
9.	213′4″	56′2″	G	18	175	67	1:9	1:3	1:5.5	200	6½
10.	219′9″	45′	WR,G	3	200	16	1:9	1:9	1:9	200	2½
11.	226′3″	43′5″	WR,Do	13	200	6	1:9	1:9	1:9	200	1½
12.	234′	54′8″	SR,G,Do	8	200	8	1:9	1:9	1:9	200	2
13.	242′5″	29′2″	G	18	200	6	1:9	1:9	1:9	200	2
14.	252′1″	17′	G,SR	20	180	113	1:9	1:3	1:6.5	200	17
15.	257′4″	36′6″	G	13	180	6	1:9	1:9	1:9	200	1
16.	264′8″	24′3″	WR,G	14	200	16	1:9	1:9	1:9	200	4
17.	267′3″	34′	WR'G	18	100	96	1:9	1:6	1:8	200	11½
18.	271′11″	22′5″	WR,G	17	180	2	1:9	1:9	1:9	200	1
19.	280′	21′6″	WR,G	12	150	353	1:9	1:3	1:5	200	53
20.	280′1″	40′	WR,G	13	200	25	1:9	1:9	1:9	200	5½
21.	279′9″	90′7″	WR,G	19	180	*1.5	1:9	1:9	1:9	200	1
22.	218′9″	67′6″	WR,G,Do	12	190	47	1:9	1:6	1:8	200	6
23.	231′5″	52′	WR,G	4	190	53	1:9	1:7	1:8	200	4½
24.	237′10″	46′	WR,G,Do	6	175	3	1:9	1:9	1:9	200	1
25.	225′6″	42′2″	WR,SR,G	13	190	4	1:9	1:9	1:9	200	½

NOTE: WR—Weathered Rock. G—Gneiss. SR—Sandy Rock. Do—Dolorite. MS—Mica Schist.
*—Grout was found to come out from Hole 19

House were shallow grouted. The entire area of the exposed rock surfaces forming the walls of the main hall were pierced through with holes upto 30′ deep at 9′ centres in a checker pattern. Pneumatic drifters mounted on stagings were used for the purpose. A movable drilling rig with platforms at various levels was made by modifying a sheet pile driving frame. This proved very useful and drilling was done simultaneously at various levels. In table 4 are shown the details of grouting done.

BACK FILL GROUTING FOR PENSTOCKS

The water from the reservoir is led to the turbines through three penstocks of diameters tapering from 14′ at the mouth to 13′.

Each penstock consists of a 18′ horseshoe-shaped tunnel and 20′ diameter vertical shaft (as may be seen from Fig. 1) excavated in rock inside which steel plate liners in segments are welded end to end. The space between the rock surface and the liner is filled in by concrete.

TABLE 2

FINAL CURTAIN GROUTING

Sl. No.	Depth of hole Rft.	Depth of over-burden Rft.	Total Redrilling Rft.	Nature of Core	Cement pumped Cft.	CEMENT : WATER (By Volume)			Maximum Pressure lbs/sq.in	Time taken days		Direction of hole away from Power House	Distance from C.L of Power House Upstream
						Initial	Final	Average		Drilling	Grouting		
1.	135′	13′6″	69′	SR,HR	276	1:9	5:4	1:2.3	200	12	3	Vertical	0′
2.	116′	21′	76′	SR	12	1:9	1:4	1:7	200	12	1	Vertical	0′
3.	139′	24′	43′	HR	23	1:9	1:4	1:6	200	13	2	3° 59½′	15′
4.	143′	8′	62′	SR HR	56	1:9	1:2	1:5	200	10	2	3° 59½′	15′
5.	139′	15′	28′	HR	14.5	1:9	1:2	1:7	200	9	½	3° 59½′	15′
6.	88′	9′	16′	HR	35	1:9	1:3	1:5	200	6	2	6° 18½′	15′
7.	88′	10′6″	17′	SR,HR	27	1:6	1:3	1:4	200	5	½	6° 18½′	15′
8.	141′1″	16′	Nil	HR,LR	36	1:9	1:2	1:3.5	200	10	½	4° 15½′	15′
9.	140′1″	15′	127′3″	HR,LR	90	1:9	1:1.5	1:3.5	180	14	½	4° 5½′	15′
10.	101′11″	8′5″	37′3″	HR,LR	25	1:9	1:2	1:4.5	200	7	½	4° 5½′	15′
11.	84′2″	21′	24′6″	SD,SR	34	1:9	1:1	1:4	200	5	½	6° 27′	15′
12.	84′	31′10″	46′10″	SD,SR	12.5	1:9	1:6	1:8	200	7	½	6° 27′	15′
13.	82′2″	27′6″	81′	SD,SR	70	1:9	1:2	1:5.5	200	9	1	4° 5½′	15′
14.	137′1″	30′	Nil	SR,HR	11	1:9	1:4	1:7	200	5	½	6° 14½′	10′
15.	135′	27′	78′7″	SR,HR	78	1:9	1:1	1:3	200	11	1	6° 14½′	7½′
16.	82′11″	26′	51′2″	SD,SR	30	1:9	1:2	1:4.4	200	7	½	4° 30′	10′
17.	82′4″	14′	49′2″	SR,HR	11	1:9	1:4	1:6.3	200	13	½	Vertical	0′
18.	104′8″	28′	Nil	SR,HR	151.5	1:9	1:1	1:1	200	6	1	Vertical	0′
19.	116′2″	21′	Nil	Sand Pebbles	13	1:9	1:6	1:6	200	9	½	Vertical	0′

NOTE: SR—Sand Rock, HR—Hard Rock, SD—Stone Dust.

TABLE 3

DETAILS OF BLANKET GROUTING

Serial. No.	Depth of hole in Rft.	WATER TEST		Cement pumped in CFT	CEMENT : WATER (by volume)			Maximum pressure lbs/sc. in.	TIME TAKEN	
		Loss in g.p.m.	pressure lbs/sc. in.		Initial	Final	Average		Drilling days	Grouting hours
1.	82′8″	7	40	22	1:9	1:2	1:4	70	4	3
2.	67′2″	1	80	3	1:9	1:6	1:7	70	6	1
3.	50′6″	10	40	5	1:9	1:4	1:7	70	3	1
4.	55′6″	4	30	4	1:9	1:9	1:9	80	3	1
5.	144′	—	—	41	1:9	1:4	1:5	80	4	8
6.	149′6″	—	—	16	1:9	1:4	1:6	80	5	3
7.	133′4″	—	—	9	1:9	1:6	1:7	85	12	4
8.	54′6″	8	50	17	1:9	1:4	1:5.5	75	3	3
9.	54′8″	6	50	3	1:9	1:9	1:9	75	4	1
10.	83′3″	7	60	8	1:9	1:4	1:6	80	6	2

The limited working space, inaccessibility of certain locations like the apex, and continuous seepage of water along the rock surface made it impossible to obtain a complete and homogenous filling of concrete. This would not only affect the stability of the penstock liner, but would endanger the very Power House by the seepage water which would find its way into and flood the Power House. Hence for filling up the voids and making the concrete water tight, low pressure grouting was resorted to. For this purpose M. S. 1″ dia grout and vent pipes were provided in the crown of the horizontal and upper elbow sections. A few additional pipes were provided in the elbow sections at the sides also. The pipes extended from the liner right up to the rock surface. The hand grouting pump was employed for the work. In the concrete bellmouth portion of penstock No. 3 it was found that water was leaking profusely. To stop this leakage 15′ holes were drilled by diamond drills and were grouted with pneumatic grout pumps. This grouting completely eliminated the seepage. Out of 111 pipes provided, grout was injected into 37 holes only. The rest of the holes had been choked up while grouting. The table 5 shows the particulars of the pipes grouted.

BACK FILL GROUTING FOR TURBINE VAULTS

For locating the Scroll Case of the Turbine, three niches were excavated in rock with passages leading to the main hall as may be seen from Fig. 1.

The scroll cases were erected in these niches over concrete pedestals. After the erection was completed, the voids between the rock surface and the spiral cases were filled in by mass concrete layer by layer. As the concrete filling rose higher and higher, the space became more and more congested. Finally at the crown it was found impossible to do any concreting. For filling up these voids and also those between concrete and the rock surface, 1½″ dia M. S. grout and vent pipes were embedded at each location. After the concreting was completed, these pipes were pressure grouted with neat cement and water, by the pneumatic duplex pump. This grouting stopped all the seepage water. The details of the grouted pipes are in Table 5.

BACK FILL GROUTING FOR DRAFT TUBES

The draft tubes consisting of steel plate liners tapering from 19′ 6″ dia to 10′ diameter, were located in tunnels extending from the turbine vaults into the surge chamber, with the space between rock and liner surfaces being packed in by concrete. The conditions and the nature of grouting operations were similar to those at the penstocks.

M. S. 1″ dia grout and vent pipes had been provided through the liner to the rock surface at the

TABLE 4
PARTICULARS OF CONSOLIDATION GROUTING

Serial No. Location	No. of holes	Total depth of holes rft.	Cement pumped cft.	CEMENT : WATER			Max. pressure PSI
				Initial	Final	Average	
1. Mucking shaft closure plug ..	7	182	817	1:9	1:1	1:2.4	80
2. Upstream wall ..	164	4680	2454	1:9	1:1	1:3	50
3. Downstream wall ..	41	985	1625	1:9	1:1	1:2.4	50
4. Service bay end wall ..	28	727	335	1:9	1:1	1:4.7	50
5. Service bay junction wall ..	12	377	1159	1:9	1:1	1:2.2	50
6. Generator bay end wall ..	41	1158	514	1:9	1:1	1:3.9	50

TABLE 5
PARTICULARS OF BACKFILL GROUTING

Serial No. Location	No. of holes	Cement Pumped cft.	CEMENT : WATER (Volume)			Max. pressure P.S.I.
			Initial	Final	Average	
1. Penstock I	11	593	1:7	1:1	1:3	50
2. Penstock II	22	171	1:6	1:2	1:4	50
3. Penstock III	10	2065	1:10	1:2	1:4.1	50
4. Turbine vault I	4	854	1:9	1:2	1:3.8	50
5. Turbine vault II	8	895	1:9	1:2	1:2.6	50
6. Turbine vault III	6	775	1:6	1:2	1:3	50
7. Draft tube I	2	51	1:6	1:2	1:5	50
8. Draft tube II	5	28	1:12	1:9	1:10	50
9. Draft tube III	10	623	1:9	1:1	1:4	50
10. Diversion tunnel plug	8	1381	1:9	1:1	1:2.3	60

crown. These were grouted under low pressure by hand grouting machine. The grouting details are shown in the Table 5.

BACK FILL GROUTING FOR ROOF ARCHES

Grouting of the concrete roof arches of the main hall transformer vaults and access tunnel were done to fill up the voids between the rock surface and the top of concrete. For the purpose, G. I. pipes of dia 1″ were embedded during the pouring of concrete. The particulars of grouting are shown in Table No. 7.

DIVERSION TUNNEL PLUG

During the construction of the Main Earth Dam across the river, the off season flow was diverted through a gothic shaped Diversion Tunnel 1150′ long located on the left bank. As the lower half of this tunnel was to be utilised as the Tail Race for the Power House by means of connecting tunnels from Draft Tubes, the upstream mouth was closed by a plug of un-reinforced concrete 70′ long and of section about 30′ × 35′ high, with vertical joints. The irregular nature of the excavated rock surface and inaccessibility of certain locations made it impossible to completely fill up all the pockets especially at the crown and make the plug water tight. Hence a system of grout pipes as shown in the Fig. 5 was embedded in the concrete with access to all the pockets and the crown of the arch. A grout box was provided at each outlet to prevent the pipe from being choked up, while concreting. Grout of neat cement and water was injected by pneumatic duplex type pump at successive levels from the lowest to the crown. Each section of the plug was taken separately. Although 28 holes had been provided, grouting of only 8 holes was possible as the grout from these holes had choked up the remaining holes. A gallery which was provided for further grouting through drilled holes in case leakage was observed, was not utilised as it was found that the initial grouting itself, had practically stopped all the leakage. The particulars of the holes grouted are shown in Table 5.

SUMMARY

The results of drilling and grouting operations for the Underground Power House at Maithon are summarised in the Tables 6 & 7.

ACKNOWLEDGEMENT

We are highly indebted in the preparation of this paper to Sri K. P. Isac, Overseer, DVC for the neat, accurate and exhaustive records maintained by him during the progress of the drilling and grouting works.

TABLE 6
SUMMARY OF GROUTING OF DRILLED HOLES

Serial No. Location	Total depth of holes rft.	Total re-drilling rft.	% redrilling col. 4 / col. 3 × 100	Total cement pumped cft.	Cement per rft of drilled hole cft
1. 2.	3.	4.	5.	6.	7.
1. First curtain grouting ..	6169	1215	19.7 %	1442	0.23
2. Final curtain grouting ..	2141	805	37.6 %	1006	0.47
3. Blanket grouting	875	—	—	128	0.15
4. Consolidation grouting ..	8109	—	—	6904	0.83

TABLE 7
SUMMARY OF BACK FILL GROUTING

Location	Penstocks	Turbine vaults	Draft tubes	Diversion Tunnel plug	R Mainhall roof arch.	Transformer vault roof arch	Access Tunnel lining.
Quantity of concrete in cft.	1,00,845	1,05,867	88034	54,918	66800	29,079	76,599
Cement pumped cft.	3829	2,524	702	1,381	4347	2,490	3,578
Cement per % cft of concrete in cft.	3.8	2.4	0.8	2.5	6.5	8.5	4.7

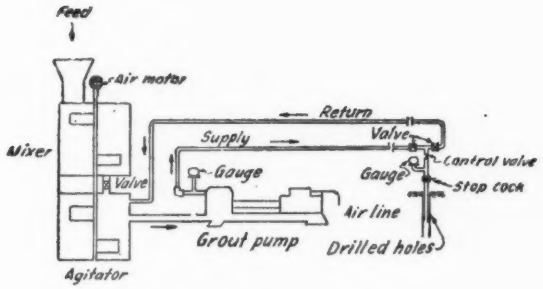


Fig. 1. Diagram of double line grouting system.

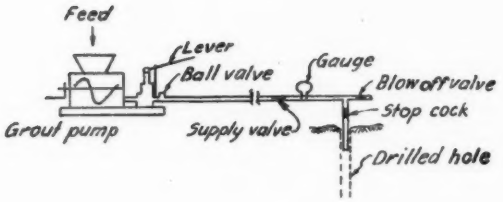


Fig 2. Diagram of single line grouting system

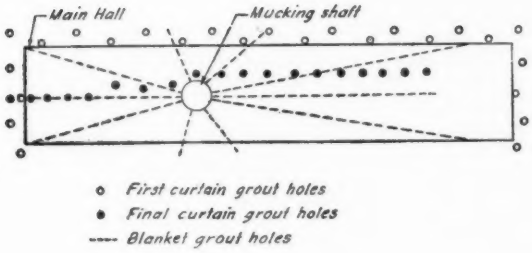


Fig. 3. Plan of main hall showing the location of grout holes.

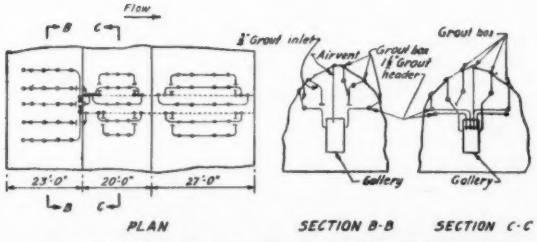


Fig. 4. The layout of the grout pipe lines in the Diversion tunnel plug.

Problems of Canal Excavation in DVC

by RAM SARUP,
Asst. Mech. Engineer (Sr.), (M.E.M. Division), Construction Plant Circle, D.V.C.

THE River Damodar was well known as a 'river of sorrows' due to the havoc created by its disastrous floods during the monsoons and afterwards run dry making people and animals alike to suffer water shortage. The Damodar Valley Corporation was formed to take up this gigantic task of harnessing this 'river of sorrows' into a 'river of hope' by construction of dams like Tilaiya, Konar, Maithon, Panchet, etc., and barrages on its tributaries and on the main river itself. Durgapur Barrage has been constructed for the prime purpose of moderating flood flow as well as to utilise the final going-waste water for navigation and irrigation by constructing the Left Bank Main Canal and the Right Bank Main Canal besides subsidiary canals for irrigation.

The practical difficulties experienced and how they were solved during the operation of earth-moving equipment in some of the extremely difficult areas of canal excavation not undertaken by contractors will be informative. The Durgapur Barrage authorities entrusted this job as usual to Mechanised Earth Moving Circle, a part of the Damodar Valley Corporation for its completion in scheduled time.

PANAGAR BRANCH CANAL (Chainage 167 to 212)

This section was full of thick jungles and ponds and as such no survey in any satisfactory manner was possible in this area. Therefore heavy bulldozers were used first for jungle clearance. Ponds were dewatered by heavy pumps before the rains and as sufficient and suitable machines such as draglines were not available, motor scrapers and bull dozers had also to be used in this slushy and swampy area.

After jungle clearance and de-watering, the area was thoroughly surveyed for earth-work calculation purposes. Toe pegs were given according to the ground level by the surveyors for demarcating the excavation line. These pegs were always shifted in as the excavation progressed. Generally the sides were cut lower than the middle till it reached the bed level.

Draglines were put into operation at the original pond sites as the motor scrapers could not be used at this stage due to the fluid and slushy nature of the soil. Dragline operations, however, could not give full progress as the soil used to flow out from the bucket. In several cases this fluid soil had to be double handled and in some cases even handled more than three times as it used to flow back into the cut from the spoil banks. On one occasion, one of the draglines sank during operations and nearly 24 hours were spent to make a ramp by heavy dozing to pull this out.

After de-rooting the ridges between one pond and another, the motor scrapers were put to operation on the same. De-rooting was necessary to avoid damage to the tyres. As soon as it was found that the soil was hard enough in the pond areas, the motor scrapers were also utilised. Many a time motor scrapers also got stuck and had to be pulled out by crawler type tractors in spite of the fact that dry soil was also pushed on top of wet soil to give better footing to the motor scrapers. Care was also taken before using the motor scrapers in pond areas to see that the level of the adjacent area of the pond had been excavated lower than the pond level to make the motor scrapers' way easier from slushy ground of pond to the hard lower surface as the weight of motor scrapers could also help in its easy propulsion to the hard lower spot. It was also the practice after excavating top dried up soil to allow further drying up of the wet soil to ease its handling next time. Wherever possible, the sides were kept lower than the middle. Mechanics and their helpers used to be on the field during operational hours to attend to the immediate field break-downs.

The machines were working daily in 3 shifts of 8 hours each including maintenance and proper lighting arrangements were made to carry out this work. On this job depreciation of machines was pretty high and for this reason maintenance cost also went up. The machines used were:—

Draglines 54 RB	2 Nos.
Laplant Choate TS 300	3 Nos.
'D' Roadster Tournapull	3 Nos.
Allis Chalmers H.D. 19	4 Nos.
International T.D. 18	1 No.

The above work was started on January 31st, 1955 and completed on April 30th, 1955 involving 10,157,000 cft.

RIGHT BANK MAIN CANAL (SALI AQUEDUCT, CHAINAGE 880.8 TO 923)

The area was actually lower than the bed level of the canal and therefore the embankments had to be

built at an average height of 20 feet. The average lead from the borrow area to the embankment was 1200 feet. The soil was of a fine sandy type. Water table was just about 2 feet below the ground level.

First of all, the area was surveyed. The toe pegs were given according to the ground level by the surveyors for showing the line for embankment filling. The operators were made to understand that the filling should start from the inner end towards the outer. The roads were well maintained for speedy operations of the machines.

The work was started at the end of November 1955 by motor and tractor scrapers. After cutting about 2 feet in one portion, the place had to be left for further drying up and the next area was used as borrow pits. Sufficient area for the borrow pits was not acquired which was done later on when the shortage of the same was brought to the notice of the Barrage and Irrigation authorities.

Water table being higher, the borrow pits were left for drying up for several days and machines had to fill the embankments in patches here and there adjacent to their respective borrow areas. Before starting the left embankment the right embankment was raised to almost sufficient height as at that time the acquired borrow area was only on the left hand side. This was done for the reason of non-availability of approach road if the left embankment was raised first. Due to the sandy nature of the soil, the machines were considerably damaged, track chains had to be renewed or repaired on crawler type tractors. The motor scrapers being of 17.5 cubic yds. heaped capacity used to get stuck much too often due to the swampy nature of the ground. On such occasions only 2 Allis Chalmers H.D. 19 tractors could pull a motor scraper out and that also with the greatest of difficulty. Tractor scrapers also used to get stuck and had to be towed out with great difficulty.

During these operations, soil from the Sali River diversion channel had to be used for filling of this embankment. After about 5 feet of this diversion channel cutting with great difficulty, this job had to be turned over to manual labour as the water table was too high for equipment's operation any deeper.

By the end of Januray it was not possible to work any more with the motor scrapers in this area and accordingly they were sent further down for canal excavation where the soil was more suitable for the operation of these machines. Only the tractor scrapers were left to complete this Sali aqueduct job by shifting from one end to the other giving time for drying up of the top sections of borrow pits from time to time. Later some more land was acquired for the right hand embankment to meet the soil shortages. The river Sali was also closed by building embankments. The work was carried out daily in 2 shifts and maintenance after every 8 hours. 2 Skoda generating sets provided lighting arrangements for working in the dark. To make the lead average the the outer end of the embankment on left bank was filled in with earth from farther end of the borrow area and earth from nearer end of borrow area was put on the inner end of the left embankment. For filling the right embankment earth from nearer end of borrow area was used on the outer end of right embankment and the earth from far end of borrow area was poured in the inner end of the embankment. This procedure was adopted when the borrow area was only on the left hand side.

The machines used on Sali Aqueduct area were:—

Caterpillar D 7	7 Nos.
Laplant Choate TS 300	3 Nos.
Allis Chalmers H.D. 19	3 Nos.
Onion scrapers EK 9	5 Nos.
Caterpillar 70 scrapers	2 Nos.

The job was completed on April 21st, 1956 involving 9,025,000 cft.

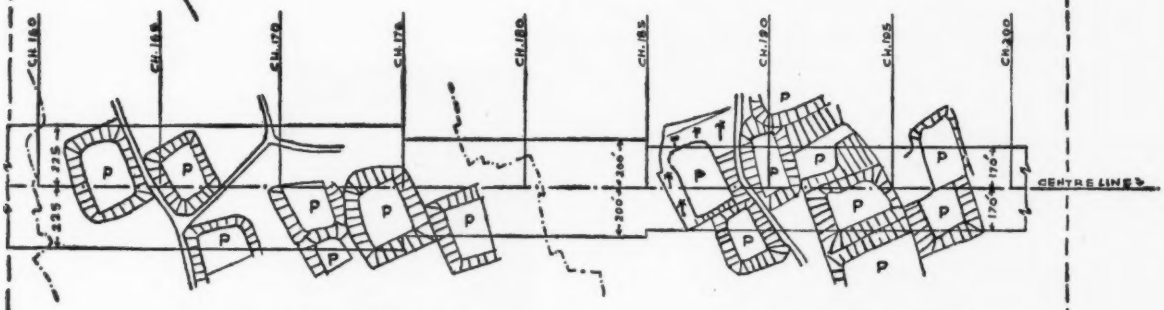
GENERAL

The surveyors with their assistants and khalasis were always on the field during operation time. On all these canal excavation jobs a vigorous check was kept on the day to day cost by posting field assistants on duty during operations. Their job was to book break-downs, idle running, stoppages and counting of scraper buckets. By number of buckets it could be ascertained that how much earth had been moved during the day compared with the machine hours. Earth work per week was calculated on actual basis and the individual machine log books showed the machine hours. For this purpose a weekly plant and progress report book was maintained, a copy of which was sent to Headquarters every week.

The success of this canal excavation work without suitable machines depended on the co-operation of field staff, close supervision, and availability of proper guidance at the spot. The great advantage in excavating canals by motor scrapers is that the spoil banks get quite a good consolidation by continuous running of machines over it during operation time thus lessening the chances of the bank washing or sliding into the canal.

LAND ACQUISITION PLAN SHOWING THE ALIGNMENT OF PANAGARH BRANCH CANAL FROM CH. 160 TO 200
SCALE 8" = 1 MILE

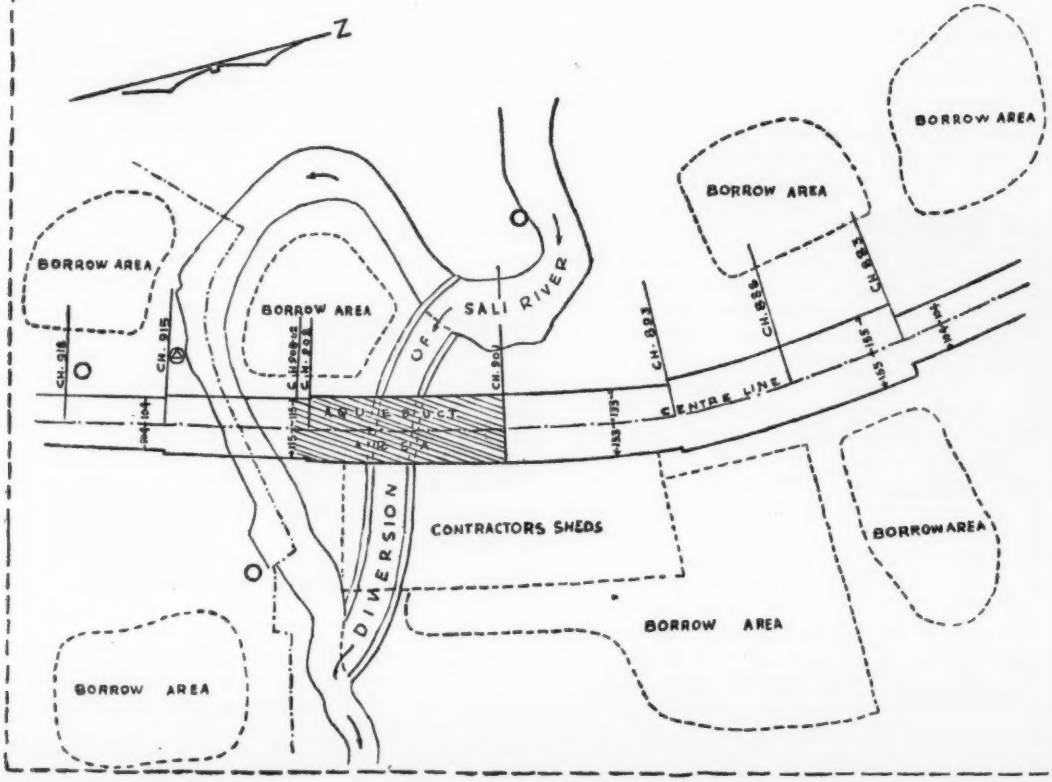
(THE AREA IS FULL OF JUNGLE & P)



MOUZA :- PANAGAR (Sheet No. 243)
J.L. NO. 85
P.S. KANKSA
DISTRICT:- BURDWAN

MOUZA :- PRAGPUR (Sheet No. 1)
J.L. NO. 80
P.S. KANKSA
DISTRICT:- BURDWAN

LAND ACQUISITION PLAN SHOWING THE ALIGNMENT OF SALI ACQUEDUCT (R.B.M.C) FROM CH. 883 TO 918
SCALE 8" = 1 MILE.



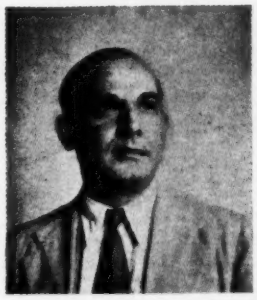
CONTRIBUTORS IN THIS ISSUE

Mr. U. K. Ghosal, I.C.S. is General Manager and Secretary of the DVC. He was previously Chairman of the Tea Board.

Mr. K. L. Dutta is Deputy Secretary of the DVC.

Mr. A. M. Komora was Chief Engineer of the DVC from 1950 to 1958. He was previously associated with the TVA. His contribution to the training of the Indian engineers in the new field of dam construction of the DVC has been considerable.

Mr. B. Parthasarathy. is the present Chief Engineer, Civil, of the Damodar Valley Corporation, having succeeded Mr. A. M. Komora, who was the Chief Engineer of the Corporation since 1950. Mr. Parthasarathy joined the Corporation in 1950 and has worked practically in all the major projects at Bokaro, Durgapur, Panchet and Maithon. Before joining the DVC Mr. Parthasarathy was with the well-known firm of Consultants Messrs. Merz and McLellan. Graduating from the College of Engineering, Bangalore in 1929 Mr. Parthasarathy has worked on many Bridge Constructions in India and Burma, under the well-known firm of bridge engineers Messrs. Braithwaite & Co. After the construction of the Ava Bridge in Burma he worked on the H. M. Naval Base at Singapore. Later he worked for the Federated State Governments and was engaged on re-construction of a large number of bridges during the Japanese occupation of Malaya. He was an active worker of the Indian Independence League and was the Civil Engineer for the Base Training Camp of the Indian National Army at Singapore under Netaji Subhas Chandra Bose.



Mr. S. Bose is Additional Chief Engineer of the DVC. He was previously with the Central Water and Power Commission (Power Wing)

Mr. S. R. Ghosh is Deputy Chief Engineer, Barrage and Irrigation, DVC.

Mr. M. K. Ghosh graduated from the Rangoon University in 1936 when he joined the New Water Supply Scheme at Gyopyu. During the war he was with the Civil Defence Organisation, CPWD and the Burma Army from 1942 to 1946 rising upto Assistant Civil Camouflage Officer, Bengal Circle, and Garrison Engineer, Construction. He was with the RangoonCorporation from 1946 to 1948. He joined the DVC in 1948 and was attached to the Maithon Dam. He was Project Officer (Civil) in-charge of Sub-Surface Investigation and later became Executive Engineer (Civil) Tilaiya Dam Project. He joined the Panchet Dam Organisation as Executive Engineer (Civil) in the Earth Dam Division and by 1956 he was Deputy Project Manager of the Panchet Hill Project. He is at present Superintending Engineer Panchet Dam and Power House.

Mr. B. N. Banerjee. After graduating in Engineering he worked as an apprentice in John Thompson Water Tube Boiler Ltd., with a special training for about a year at Metropolitan Vickers. He served for a short period at the Research Laboratory of Babcock and Wilcox. He was with the TISCO for about 5 years when he was Engineer (Power) in-charge of the Power Section of Project Engineering, Works Engineering Department. He received specialised training in the U. S. A. for one year after joining the DVC in 1949. He was associated in the construction of the Bokaro Thermal Power Station and is now Power System Engineer at the Headquarters in the DVC controlling the Engineering and Research sections of the Operation and Maintenance of the Electrical Department of the DVC.

Mr. N. M. Chakravarty graduated in Civil Engineering from Bihar College of Engineering in the year 1940. Mr. Chakravarty then joined the Design Office of M/s. Cleveland Bridge and Engineering Company, who were at that time constructing the Howrah Bridge. In 1942, he was employed in the Design Office of the Chief Engineer, Factories, from where in 1945 he joined the Central Technical Power Board and worked with the American Expert and ex-Chief Planning Engineer of Tennessee Valley Authority, Mr. W. L. Voorduin.

Mr. Chakravarty's services were taken over by Damodar Valley Corporation after the formation of the Corporation in 1948. He was sent to U. S. A. under the T. C. M. Plan for training in design. Mr. Chakravarty is now head of the Civil Design Organization of Damodar Valley Corporation.

Mr. S. S. Rao is Project Officer in the DVC.

Mr. A. K. Sen Gupta is Executive Engineer, Barrage and Irrigation, DVC.

Mr. N. S. Iyengar is at present Manager of the Reservoir Operations of the DVC.

Mr. S. S. Pillai was Superintending Engineer Construction Plant Circle of the DVC. He has considerable experience of earthmoving equipments.

Mr. S. B. Deb is Project Engineer in the Electricity Department of the DVC.

Mr. B. B. Chatterjee is Inspection Engineer of the DVC.

Mr. A. C. Das Gupta is Executive Engineer of the DVC.

Mr. S. R. S. Rao is Assistant Engineer at the Panchet Dam.

Mr. M. L. Subba Rao is Assistant Engineer in the DVC.

Mr. R. Sarup is Assistant Mechanical Engineer (Sr) in the MEM Division of the DVC.

CANADA
FINLAND
U.S.A.
INDIA
N. ZEALAND
FERRANTI
TRANSFORMERS
F
FERRANTI
INDIA Five 3-phase transformers, three 20 MVA, 132/33-66 kV and two 10 MVA, 132/33 kV, have been supplied for the Damodar Valley Power Scheme.
NEW ZEALAND Twenty-six 220 kV single-phase transformers have been ordered by the State Hydro-Electric Department of New Zealand. Thirteen have already been supplied.
U.S.A. Of nine 33.3 MVA, 230 kV single-phase transformers being supplied to the U.S. Army Corps of Engineers for the Garrison Dam Project, N. Dakota, three have been shipped.
CANADA Four 300 kV, 71 MVA and three 275 kV, 37 MVA transformers have been supplied to the Aluminum Company of Canada for the Alcan Project at Kemano and Kitimat.
FERRANTI TRANSFORMERS FAMOUS THROUGHOUT THE WORLD

FERRANTI LTD.

HOLLINWOOD. LANCASHIRE, ENGLAND.

Indian Distributors :

BRITISH INSULATED CALLENDER'S CABLES LIMITED,

Esplanade House, Waudby Road, Fort, Bombay-1. Post Box 111

Printed and published by P. K. Menon from Inland Printing Works, 60/3 Dharamtala Street, Calcutta-13
Editorial & Managerial Office : 6-2 Madan Street, Calcutta-13

Regd. No. C-3873

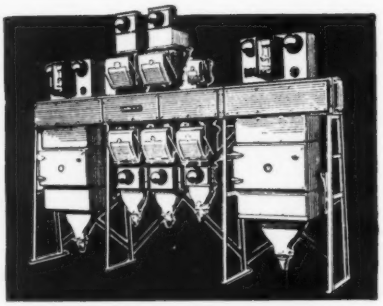
'ENGLISH ELECTRIC'

HIGH RUPTURING CAPACITY HEAVY DUTY

FUSEGEAR

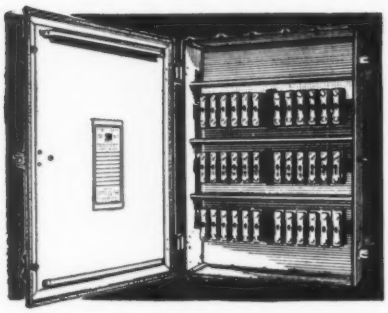
COMBINATION FUSE-SWITCHES

Ratings from 30 to 300 amps—Rugged construction, fully shrouded and inter-locked—Type tested for 35 MVA rupturing capacity.



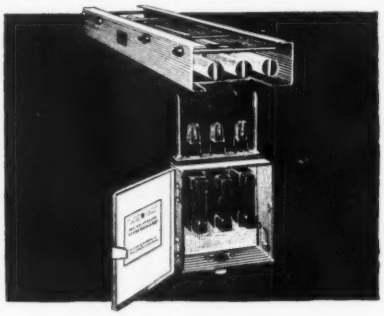
COMBINATION FUSE-SWITCHBOARDS

Incorporating Combination Fuse-S vitches upto 750 amps—Robust and compact construction. Readily modified and extended. Type tested for 35 MVA rupturing capacity.



DISTRIBUTION FUSE-BOARDS

Robust, dust and moisture proof construction —Type tested for 35 MVA rupturing capacity —Ratings from 15 to 100 amps.



OVERHEAD BUSBAR EQUIPMENT

Flexibility of power distribution—Can be installed without disturbing existing layout or production—Avoids chasing of floors for ducting —Approved by Fire Insurance Authorities.

'MANUFACTURED AT OUR WORKS IN MADRAS — THE ABOVE EQUIPMENT IS FITTED WITH 'ENGLISH ELECTRIC' H.R.C. CARTRIDGE FUSE LINKS

THE ENGLISH ELECTRIC COMPANY LIMITED

(Incorporated in England. Liability of Members Limited)

New Delhi Calcutta Bombay Madras Lucknow

Agents for South India: BINNY & COMPANY (MADRAS) LTD., MADRAS

EE^ 4*